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ART. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Eleventh paper. With plates I and II.

[Read before the National Academy of Sciences, Washington, April 15, 1879.]

The Winds on Mt. Washington compared with the winds near the level of the sea.

IN my last Article I gave some reasons for believing that areas of low pressure sometimes result from a circulation of the surface winds which does not extend to the height of 6,000 feet. In order to investigate this subject more fully, I selected from the published volumes of the Signal Service observations all those cases in which the direction of the wind on Mt. Washington differed at least 90° from that at each of the stations, Burlington, Boston, and Portland, Me. The number of these cases was 507. Three-fifths of these cases occurred when the wind on Mt. Washington was from the west or northwest, and more than four-fifths of them occurred when the wind on Mt. Washington was from one of the points N., N.W., W. or S.W.; and at the same time the wind at the neighboring surface stations was generally from one of the points S., S.E., E. or N.E. As this Table, if accompanied with the details necessary to render it intelligible, is too large for publication, I have adopted a different standard of selection, and have taken all those cases in which the barometer at Portland, Me., fell as low as 29·6 inches. This list has already been given in my tenth paper, page 9, except that I have added the cases found in the volumes of observations since published for January, February and

Table I.— *Winds on Mt. Washington compared with the surface winds.*

	1872.												
1	Oct.	12.2	S.W.	5	12.3	W.	30	13.1	S.W.	27	13.2	N.W.	30
			S.	4		S.	6		S.	9		S.E.	12
2		25.3	N.W.	15	26.1	S.E.	24	26.2	S.W.	29	26.3	S.W.	18
			E.	2		N.E.	6		N.E.	5		N.E.	7
3	Nov.	6.1	N.W.	20	6.2	N.W.	28	6.3	N.W.	30	7.1	S.E.	4
			S.	3		S.	9		S.	8		S.E.	3
4		11.1	calm.		11.2	W.	13	11.3	S.E.	50	12.1	S.W.	28
			S.	2		S.	10		S.	7		S.	8
5		13.2	N.W.	5	13.3	S.	15	14.1	W.	55	14.2	S.	30
			N.	4		S.E.	4		S.E.	5		S.E.	5
6		28.3	S.W.	22	29.1	N.E.	22	29.2	S.W.	35	29.3	S.W.	22
			S.	4		S.E.	9		N.W.	9		W.	10
7	Dec.	1.3	W.	32	2.1	S.E.	25	2.2	W.	35	2.3	S.	42
			S.	5		S.	4		S.	4		S.W.	5
		3.3	S.E.	42	4.1	W.	58						
			W.	7		W.	9						
8		7.3	W.	8	8.1	S.E.	49	8.2	S.E.	54	8.3	N.W.	22
			S.	7		S.	9		S.	8		S.	5
9		26.1	N.W.	16	26.2	N.E.	2	26.3	S.	5	27.1	calm.	
	1873.		N.E.	5		N.E.	10		N.	8		N.W.	5
10	Jan.	2.2	S.W.	38	2.3	S.	36	3.1	S.W.	48	3.2	W.	36
			N.E.	3		N.E.	5		S.	5		S.W.	6
11		4.3	W.	50	5.1	W.	36	5.2	S.	64	5.3	S.	60
			W.	5		N.E.	2		N.E.	13		*N.E.	4
12		20.3	S.W.	54	21.1	W.	16	21.2	S.W.	28	21.3	S.W.	34
			S.	5		S.	1		S.	6		N.E.	4
13		26.2	W.	10	26.3	N.W.	28	27.1	N.	10	27.2	S.W.	6
			W.	3		E.	2		E.	1		N.E.	7
14	Feb.	3.1	W.	44	3.2	S.W.	40	3.3	W.	32	4.1	S.W.	46
			S.W.	11		S.W.	6		S.	6		S.	7
15		6.3	W.	44	7.1	W.	14	7.2	S.	30	7.3	S.	34
			S.W.	4		N.	2		N.E.	5		N.E.	10
16		21.1	W.	40	21.2	S.	38	21.3	S.	12	22.1	S.E.	26
			N.E.	3		E.	12		*N.E.	12		W.	12
17	March.	2.3	W.	12	3.1	W.	37	3.2	N.E.	30	3.3	N.E.	42
			N.W.	3		N.	8		*N.E.	13		N.	15
18		7.2	W.	36	7.3	W.	50	8.1	W.	16	8.2	S.	46
			S.	6		S.	8		S.	9		S.	8
19		15.1	W.	12	15.2	S.W.	17	15.3	S.	38	16.1	S.	38
			S.	5		S.	8		S.E.	8		*S.	8
20		20.1	N.W.	5	20.2	S.E.	2	20.3	S.E.	84	21.1	S.E.	50
			E.	6		E.	7		N.E.	14		*W.	10
21		22.2	W.	32	22.3	W.	41	23.1	N.W.	38	23.2	W.	—
			W.	5		W.	7		S.W.	4		S.	8
22		25.2	S.W.	24	25.3	S.W.	40	26.1	S.W.	23	26.2	S.	54
			N.E.	4		N.E.	5		N.E.	10		N.E.	9
23		28.3	W.	76	29.1	S.W.	34	29.2	S.W.	17	29.3	S.W.	50
			S.	8		S.	5		S.E.	12		S.	13
24		30.3	N.W.	24	31.1	N.W.	42	31.2	S.	24	31.3	S.	82
			S.W.	2		S.	4		*N.	9		W.	9
25	April.	11.3	N.W.	10	12.1	S.	36	12.2	N.E.	70	12.3	E.	96
			N.E.	3		N.E.	7		N.E.	10		N.E.	11
26		18.1	N.	60	18.2	S.E.	20	18.3	S.E.	6	19.1	calm.	
			N.E	10		N.E.	8		N.E.	4		N.	5
27		24.3	N.	5	25.1	W.	12	25.2	S.E.	5	25.3	S.E.	5
			W.	7		W.	6		W.	6		W.	4
28	May.	12.1	N.	22	12.2	N.W.	40	12.3	N.W.	56	13.1	W.	44
			N.W.	4		N.W.	5		S.	5		S.	7
29		23.1	W.	24	23.2	W.	13	23.3	W.	60	24.1	W.	40
			S.	4		S.	9		S.	9		S.	7

1	Oct.	13.3	N.	59	14.1	S.W.	22						
			N.E.	8		*N.	4						
2		27.1	N.E.	4	27.2	N.E.	29						
			*N.	8		N.	8						
3	Nov.	7.2	S.W.	38	7.3	N.W.	65						
			*W.	9		W.	8						
4		12.2	S.W.	65	12.3	N.	50						
			S.	8		*N.	14						
5		14.3	W.	32	15.1	W.	38						
			*W.	4		W.	10						
6		30.1	N.E.	45	30.2	S.W.	27						
			*W.	13		S.W.	14						
7	Dec.	3.1	S.E.	51	3.2	S.E.	60						
			*W.	13		W.	9						
		9.3	S.E.	16	10.1	W.	59						
			N.W.	15		N.W.	15						
8		9.1	calm.		9.2	S.W.	10						
			S.	2		*N.W.	10						
9		27.2	N.W.	24	27.3	S.W.	41						
			*N.W.	7		N.W.	10						
10	Jan.	3.3	W.	42	4.1	S.W.	56						
			*W.	4		W.	8						
11		6.1	W.	32	6.2	W.	60						
			W.	12		W.	9						
12		22.1	S.W.	26	22.2	N.W.	40						
			*N.W.	4		N.W.	7						
13		27.3	S.W.	16	28.1	W.	28						
			*N.	7		S.W.	5						
14	Feb.	4.2	W.	44	4.3	W.	64						
			*S.W.	6		N.W.	6						
15		8.1	S.W.	18	8.2	S.W.	50						
			*W.	8		W.	6						
16		22.2	S.E.	36	22.3	W.	52						
			N.W.	12		N.W.	9						
17	March.	4.1	S.E.	48	4.2	N.W.	36						
			N.	9		N.W.	7						
18		8.3	N.W.	126	9.1	N.W.	89						
			*W.	8		W.	12						
19		16.2	S.W.	52	16.3	W.	28						
			W.	13		N.W.	18						
20		21.2	W.	12	21.3	W.	29						
			W.	10		W.	11						
21		23.3	N.W.	43	24.1	W.	48						
			*W.	9		N.W.	9						
22		26.3	W.	35	27.1	N.W.	60						
			*N.	8		N.W.	12						
23		30.1	W.	18	30.2	W.	44						
			*N.	7		W.	17						
24		32.1	S.	20	32.2	N.W.	14						
			W.	4		W.	4						
25	April.	13.1	N.E.	58	13.2	N.W.	46						
			N.E.	11		N.	10						
26		19.2	W.	36	19.3	W.	24						
			*N.	5		N.	1						
27		26.1	S.E.	10	26.2	W.	46						
			*N.W.	7		N.W.	10						
28	May.	13.2	N.W.	51	13.3	N.W.	48						
			*W.	8		W.	6						
29		24.2	W.	60	24.3	W.	72						
			*W.	7		N.W.	6						

Winds on Mt. Washington compared with the surface winds.

	1873.						
30	June.	3.1 N.W. 6	3.2 W. 14	3.3 W. 10	4.1 N.W.24	4.2 W. 36	4.3 N.W.30
		N.E. 8	E. 6	S. 7	S. 7	S. 8	*N. 5
31		18.3 N.W.48	19.1 N.W.24	19.2 W. 30	19.3 W. 41	20.1 N.W.26	20.2 N.W.36
		S.W. 7	S.W. 4	S.W. 5	S. 7	*W. 6	N.W.12
32	Sept.	0.1 W. 40	0.2 N.W.30	0.3 N.W.10	1.1 S.W. 20	1.2 S.W. 50	1.3 N.W.60
		S.W. 5	W. 2	N.E. 3	S. 7	*W. 10	W. 12
33	Oct.	6.1 N.W.35	6.2 S.W. 8	6.3 S.W. 18	7.1 N.E 12	7.2 N.E. 20	7.3 N. 30
		S.E. 3	N.E. 7	N. 10	*N. 11	N. 7	N. 6
34		10.3 S. 20	11.1 S. 20	11.2 S.E. 18	11.3 S.E. 20	12.1 S.W. 10	12.2 W. 20
		S. 3	S. 4	S. 6	S. 4	W. 3	*W. 8
35		26.1 N.W.20	26.2 N.W. 8	26.3 N.W.45	27.1 S.W. 55	27.2 N.W.35	27.3 N.W.45
		S.W. 3	S. 7	S. 12	S. 16	*W. 12	N.W. 8
36	Nov.	6.3 N.W.38	7.1 N.W.38	7.2 S.W. 12	7.3 calm.	8.1 S.E. 30	8.2 N.W.28
		E. 5	S. 4	S.E. 9	S.E. 6	N.E. 9	*W. 6
37		11.2 N.W.34	11.3 N.W.10	12.1 S.E. 46	12.2 W. 22	12·3 N.W.28	13.1 W. 30
		S. 4	S. 3	S.E. 12	W. 6	*W. 5	N.W,12
38		15.3 N.W. 6	16.1 N.W.30	16.2 S.E. 34	16.3 S.E. 10	17.1 S.E. 6	17.2 S.E. 22
		E. 3	N.E. 4	N.E. 7	N.E. 7	N.E. 7	N.E. 10
				17.3 S.E. 56	18.1 E. 48	18.2 S.E. 5	18.3 N.W.49
				N.E. 14	N.W.17	*N.W.12	N.W. 7
39	Dec.	2.3 S.W. 40	3.1 S.W. 42	3.2 W. 52	3.3 S.W. 47	4.1 S.W. 65	4.2 W. 80
		S. 10	S. 6	S. 12	S. 11	S. 16	*W. 12
40		12.2 N.W.28	12.3 N.W.23	13.1 calm.	13.2 S.E. 23	13.3 calm.	14.1 N.W.65
		W. 3	N. 4	N.E. 7	N.E. 11	*N. 11	N.W. 8
41		25.2 N.W.28	25.3 N.W. 3	26.1 N.W.22	26.2 E. 24	26.3 calm.	27.1 N.W.28
		N. 5	N.E. 3	N.E. 5	N.E. 8	*N. 9	N. 7
42		27.1 N.W.28	27.2 N. 10	27.3 S.E. 24	28.1 N.E. 28	28.2 N.W.96	28.3 N.W.85
		N. 7	N.E. 6	N.E. 11	*N.W.17	N.W.12	N.W. 6
43	1874. Jan.	7.2 S.W. 54	7.3 S.W. 46	8.1 S.E. 62	8.2 S.W. 46	8.3 S.W. 45	9.1 N.W.35
		N. 4	N.E. 1	S. 13	*S. 15	S.W. 10	S.W. 6
44		9.1 N.W.35	9.2 N.W.16	9.3 N.W.25	10.1 S.W. 45	10.2 W. 30	10.3 W. 15
		S.W. 6	S. 5	S. 2	S. 7	*S.W. 5	S.W. 3
45		13.2 N.W.10	13.3 S. 15	14.1 S.E. 34	14.2 N.W.10	14.3 N.W.48	15.1 N.W.42
		N. 3	E. 4	N. 16	N. 13	N.W. 7	N.W. 5
46		21.3 N.W.64	22.1 S.W. 58	22.2 W. 60	22.3 S.W. 52	23.1 W. 37	23.2 W. 80
		S. 4	S. 8	S. 6	S. 12	S. 12	*S.W. 13
47		26.3 N.W.68	27.1 N.W.35	27.2 N.W.32	27.3 W. 10	28.1 N.W.25	28.2 S.W. 50
		N. 1	S. 8	S. 7	S. 8	S. 3	*N.W. 9
48	Feb.	9.2 N.W. 8	9.3 S.W. 4	10.1 N.W. 2	10.2 N.W.45	10.3 N.W.82	11.1 N.W.90
		calm.	calm.	N.W. 5	N.W.11	*N.W.12	N.W. 7
49		12.2 N.W.36	12.3 S.W. 20	13.1 S.W. 44	13.2 S.W. 48	13.3 S.W. 58	14·1 W. 72
		E. 5	S. 8	S. 11	S. 14	S. 14	*W. 12
50		15.1 N.W.19	15.2 S. 32	15.3 S. 40	16.1 S.W. 18	16.2 N.W.55	16.3 N.W.72
		N. 5	S. 10	S. 12	S. 12	S.W. 12	*W. 16
51	March.	2.3 N.W.56	3.1 N.W.38	3.2 S.W. 60	3.3 S.W. 96	4.1 S.W. 74	4.2 N.W.52
		S. 11	S. 8	S. 11	S. 9	S. 13	*N.W.14
52		8.1 N.W.54	8.2 N.W.50	8.3 N.W.58	9.1 N.W.50	9.2 N.W.20	9.3 N. 23
		S. 6	W. 10	W. 11	W. 15	*N.W.15	N.W.13
53		18.1 W. 50	18.2 W. 36	18.3 W. 14	19.1 W. 10	19.2 W. 44	19.3 W. 77
		S. 9	S. 6	S. 2	S. 2	S. 12	*W. 11
54		21.2 N.W.38	21.3 N.W.37	22.1 N.W.40	22.2 N.W.47	22.3 N.W.20	23.1 N.W.74
		S.W. 14	S.W. 9	W. 8	N.W.13	*S. 7	N.W.18
55		25.2 N.W.54	25.3 N.W.78	26.1 N.W.48	26.2 N.W.34	26.3 N.W.59	27.1 N.W.67
		S.W. 23	S.W. 19	S. 8	N. 8	*W. 13	N.W.11
56	April.	1.2 N.W.13	1.3 W. 19	2.1 N.W.15	2.2 S.W. 6	2.3 W. 24	3.1 W. 24
		S. 8	S.E. 5	S. 4	S. 12	S. 10	*W. 8
57		14.1 N.W.55	14.2 W. 36	14.3 W. 47	15.1 N.W.55	15.2 S.W. 52	15.3 N.W.40
		S. 9	S. 13	S. 13	S. 8	*S. 8	W. 13
58		19.3 N.W.72	20.1 E. 6	20.2 S. 60	20.3 S. 36	21.1 N.W.67	21.2 N.W.58
		N. 7	N.E. 11	E. 9	N.E. 14	*S.W. 5	N.W.14
59		24.3 N.W.23	25.1 calm.	25.2 E. 16	25.3 E. 58	26.1 E. 90	26.2 N. 50
		calm.	E. 6	E. 9	E. 13	*N.E. 18	N. 21
60		28.1 N.W.86	28.2 S.E. 2	28.3 S. 5	29.1 E. 35	29.2 E. 18	29.3 N.W.12
		N.W.11	N. 5	calm.	N. 11	N. 17	N. 18

Winds on Mt. Washington compared with the surface winds.

	1874.							
61	May.	4.2 N.W.28	4.3 N.W.48	5.1 N. 19	5.2 N.W.24	5.3 N.W.36	6.1 N.W.20
		W. 7	N.W. 6	N.E. 7	*N.E. 8	N.W. 5	N. 8
62		24.2 N.W.18	24.3 W. 10	25.1 S.W. 56	25.2 S. 88	25.3 W. 56	26.1 W. 42
		S. 6	S. 3	S.E. 13	S.E. 13	*S.W. 11	S.W. 10
63		30.1 N.W.32	30.2 N.W.30	30.3 W. 36	31.1 N.W.38	31.2 N.W.50	31.3 N.W.40
		E. 6	S.E. 7	S. 5	S. 9	*S.W. 20	N. 8
64	June.	6.2 N.W.20	6.3 N.W.24	7.1 N.W.20	7.2 W. 36	7.3 W. 68	8.1 W. 90
		E. 6	S.E. 3	S.E. 5	S.E. 8	S. 7	*W. 8
65		16.1 W. 20	16.2 S. 36	16.3 S. 60	17.1 N.W.36	17.2 S. 20	17.3 W. 24
		S. 3	S. 12	S. 14	S. 11	S.W. 7	*W. 5
66		22.1 N. 28	22.2 N. 44	22.3 N.W.42	23.1 N.W.60	23.2 N.W.34	23.3 N.W.52
		S. 8	S. 8	S.W. 8	S. 10	*S.W. 9	N.W.12
67		27.2 W. 18	27.3 W. 23	28.1 N.W.25	28.2 N. 36	28.3 W. 54	29.1 N.W.24
		S. 9	S. 11	S. 7	*S. 10	S.W. 11	S.W. 7
68	Aug.	0.1 N.W.16	0.2 S.W. 50	0.3 N.W.52	1.1 N.W.60	1.2 N.W.75	1.3 N.W.70
		S. 5	S. 14	S.W. 11	S.W. 10	*W. 9	N.W. 5
69	Sept.	29.1 W. 16	29.2 S.E. 10	29.3 E. 54	30.1 N.W.30	30.2 N.W.84	30.3 N.W.64
		W. 5	N.E. 11	N.E. 8	*N.W.14	N.W.13	W. 12
70	Oct.	1.1 N.W.20	1.2 N.W.36	1.3.N.W.40	2.1 S.W. 38	2.2 N.W.25	2.3 N.W.56
		W. 11	W. 13	S. 8	S. 13	*S.W. 10	W. 11
71		9.2 N.W.55	9.3 N.W.55	10.1 S.W. 30	10.2 S. 35	10.3 W. 40	11.1 N.W.54
		S.W. 8	S. 5	S. 10	S. 11	*S.W. 12	W. 11
72		16.3 N. 40	17.1 W. 30	17.2 W. 28	17.3 N.W.18	18.1 N. 24	18.2 N. 34
		S.W. 6	S.W. 6	S.W. 10	S.W. 7	*N.W. 6	N.W.12
73	Nov.	9.3 N. 56	10.1 N. 74	10.2 N. 70	10.3 W. 46	11.1 N. 78	11.2 N. 70
		S.W. 7	W. 9	W. 4	S. 6	*W. 5	N.W.19
74		19.2 N. 50	19.3 N. 34	20.1 S. 24	20.2 S. 60	20.3 S. 40	21.1 N.W.30
		W. 6	S. 4	S. 5	S. 7	*S. 6	N.W. 8
75		22.2 N. 8	22.3 N.W.18	23.1 S.E. 54	23.2 S.E. 35	23.3 N.W.32	24.1 N. 48
		N. 3	S.E. 5	S.E. 12	S.W. 11	*W. 8	W. 13
76		28.1 N.W.50	28.2 S.W. 36	28.3 S. 70	29.1 S.W. 60	29.2 N. 84	29.3 N.W.88
		S.W. 5	N.E. 3	S. 7	N.W.13	*W. 6	W. 11
77	Dec.	16.1 N. 25	16.2 N.W.38	16.3 N.W. 8	17.1 N.W.54	17.2 N.W.35	17.3 N.W.60
		calm.	S.E. 4	S.E. 4	S.E. 7	W. 7	*N.W.16
78		22.2 W. 40	22.3 W. 40	23.1 N. 40	23.2 N.W.48	23.3 N.W.24	24.1 W. 40
	1875.	S. 10	S. 7	S. 5	S.W. 5	S. 8	S.W. 7
79	Jan.	1.1 N.W.80	1.2 N.W.45	1.3 N.W.48	2.1 N.W.14	2.2 S.W. 30	2.3 N.W.90
	1877.	W. 9	S. 5	S. 6	S. 6	*W. 10	N.W.20
80	Jan.	1.1 N.W.50	1.2 N.W.28	1.3 calm.	2.1 N. 17	2.2 N. 56	2.3 N. 70
		W. 7	N.W. 2	N.E. 8	*N. 16	N.W.19	N.W.10
81		6.1 N.W.48	6.2 N.W.42	6.3 N.W.40	7.1 N.E. 50	7.2 N.W.96	7.3 N.W.60
		S. 3	S. 8	N.E. 3	N.E. 12	*W. 15	W. 9
82		7.3 N.W.60	8.1 N.W.60	8.2 N.W.48	8.3 N.W.54	9.1 N.W.96	9.2 N.W.60
		W. 9	S. 8	S. 15	*W. 19	N.W. 9	N.W. 5
83		19.1 N.W.46	19.2 N.W.46	19.3 N.W.62	20.1 W. 48	20.2 N.W.86	20.3 N.W.96
		calm.	S. 3	S. 6	S. 16	*W. 24	W. 14
84	Feb.	15.3 N.W.50	16.1 N.W.24	16.2 W. 36	16.3 W. 24	17.1 N. 24	17.2 N.W.60
		S. 9	S.W. 6	S.W. 8	W. 7	W. 14	N.W.17
		17.3 N.W.72	18.1 N.W. 108			25.1 N.E. 24	25.2 N. 24
		W. 13	*W. 21			*N. 11	N. 12
85		23.1 N.W. 6	23.2 N.E. 12	23.3 N.E. 30	24.1 N.E. 54	24.2 N.E. 36	24.3 N.E. 60
		N.E. 5	N.E. 4	N.E. 7	N.E. 16	N.E. 17	N.E. 18
86	March.	1.2 N.W.60	1.3 N.W. 6	2.1 S.W. 38	2.2 S. 60	2.3 S.W. 48	3.1 N.W.84
		W. 7	S. 5	S.E. 11	S. 13	*S. 15	W. 12
87		7.3 N.W.66	8.1 W. 42	8.2 W. 54	8.3 W. 72	9.1 W. 66	9.2 W. 54
		N. 3	S. 7	S. 7	S. 13	S.E. 27	*W. 31
88		12.2 N.W.72	12.3 calm.	13.1 N.E. 6	13.2 N.E. 6	13.3 N.E. 4	14.1 S. 12
		S. 6	calm.	N.E. 12	N.E. 8	calm.	N.E. 8
		14.2 S. 60	14.3 W. 40	15.1 N.W.18	15.2 N.W.72		
		S.E. 12	S. 10	N.W.10	*W. 18		
89		25.2 W. 24	25.3 S.W. 24	26.1 S.E. 72	26.2 E. 48	26.3 S.E. 78	27.1 S.E. 60
		N.E. 13	E. 10	N.E. 10	N.E. 11	N.E. 10	N.E. 9
		27.2 S.E. 60	27.3 S.E. 66	28.1 S.E. 54	28.2 S.E. 24	28.3 N.E. 18	29.1 N.E. 10
		N. 9	N. 3	N. 11	*N. 14	N.W. 9	N.W.14

March, 1877. The total number of these cases is 89, and they are shown in Table I, in which two lines are given for each date; the first horizontal line shows the direction and force of the wind on Mt. Washington for six observations near the time of barometric minimum, and the second line shows for the same dates the average direction and force of the wind at five or six of the nearest surface stations. These data are designed to indicate the average direction of the surface winds near the base of Mt. Washington as accurately as it can be derived from the observations. For each case, the date of minimum pressure at the neighboring surface stations is indicated by an asterisk.

It will be noticed that for several observations preceding the minimum pressure, the surface winds generally blew from one of the points S., S.E., E. or N.E.; and that about the time of minimum pressure the wind changed to one of the points N., N.W., W. or S.W. For convenience I call the semicircle including the four former directions the *east quarter*, and the semicircle including the four latter directions the *west quarter*. On the summit of Mt. Washington we sometimes notice a similar change of wind near the time of minimum pressure, but not invariably. There are two cases in which the change of wind from one of the above mentioned quarters to the other did not occur in a decided manner either at the base or summit of Mt. Washington. These cases are Nos. 48 and 72. In each of these cases however there were a few of the surface stations at which the wind blew for a short time from the east quarter. In No. 48 at 9.2 the wind at Boston was east, while at Burlington and Portland it was south, but the velocity at all of the stations was so small that I have preferred to record it as a calm. The center of this depression was on the southeast side of Mt. Washington. In No. 72 the winds preceding the minimum pressure at several stations blew from the south, but the prevalent direction appeared to be S.W. This low center passed on the north side of Mt. Washington. These two cases should properly be deducted from the total number of cases, leaving the number of cases considered in the subsequent comparisons 87.

There were 40 cases in which the change of wind from the west to the east quarter was felt at the base but not at the summit of Mt Washington, that is, 46 per cent of the whole number of cases; and there were two cases in which this change occurred at the summit but did not occur in a decided manner at the base. These cases are Nos. 27 and 60. In No. 27 at 25.1 the wind at Burlington was south, and at Portland was northeast, but the prevalent direction of the surface winds in the vicinity of Mt. Washington appeared to be west. It will also be observed that the wind at this time on Mt. Washington was very

feeble. In No. 60 the wind at Boston at 28.3 blew from east, and at 29.1 from northeast, but there was no prevalent surface wind from the east quarter. The center of this low area passed on the south side of Mt. Washington. We thus see that occasionally when a low center passes near Mt. Washington, there is no prevalent surface wind from the east quarter although it occurs on Mt. Washington; but out of 87 cases which have been examined only two cases of this kind have been found; while in nearly half of the whole number of cases the surface wind blew for a time from the east quarter, but on the summit of Mt. Washington it blew uninterruptedly from the west quarter. In other words, in about half of the cases in which the barometer in New England sinks to 29·6 inches, the usual change of wind to the east quarter is observed at the surface stations, but this change does not reach to the summit of Mt. Washington.

We have now 45 cases in which the change of wind from the west quarter to the east occurred both at the summit and base of Mt. Washington. In 37 of these cases the change occurred first at the base, and in 8 cases the change occurred simultaneously at the summit and the base; that is, at an interval of less than 8 hours; and taking the average of all the cases we find that the change of wind at the surface stations usually occurs eleven hours earlier than it does on Mt. Washington.

In 23 cases the change of the wind back from the east quarter to the west quarter occurred simultaneously on the summit of Mt. Washington and at the base; that is, with an interval less than 8 hours; in 16 cases the change occurred first at the base, and in 6 cases the change occurred first at the summit. These six cases were Nos. 4, 10, 43, 50, 86 and 88. In four of these cases the wind on Mt. Washington blew from the east quarter at but a single observation, while at the surface stations the east wind continued during a period of from three to five observations, indicating that the influence of the movement of the lower stratum of the air was sensible on Mt. Washington for a few hours only, and then subsided. No. 88 is the only one of these cases in which the wind on Mt. Washington blew from the east quarter during more than two observations. Taking the average of all the cases we find that the change of wind back from the east to the west quarter generally occurs at the base of Mt. Washington sooner than on the summit by five hours.

If we take the average of the pressures at the center of those low areas in which the change of wind to the east quarter did not occur on the summit of Mt. Washington, we obtain the value 29·47 inches. If we take the average of the pressures at the center of those low areas in which the change of wind to the east quarter did occur on Mt. Washington we obtain 29·27 inches, which seems to indicate that the greater the depression

of the barometer, the greater is the height to which the system of circulating winds extends. It is, however, remarkable that in several of those cases in which the change of wind to the east quarter did not occur on Mt. Washington the depression of the barometer was very great. During the period of 32 months under examination, there were 8 cases in which the barometer fell below 29 inches: viz. Nos. 23, 38, 42, 60, 75, 81, 83 and 87, and in three of these cases, viz: Nos. 23, 83 and 87, no considerable change of wind occurred on Mt. Washington. In No. 23 the wind on Mt. Washington blew uninterruptedly from the west or southwest although the center of the low area passed south of that station. In Nos. 83 and 87 the wind on Mt. Washington was strong from the west or northwest.

I have also made a comparison of those cases in which an area of low pressure has passed over New England, when the barometer at Portland, Me., did not fall to 29·6 inches, and in seven-eighths of these cases during the continuance of this low pressure the wind on Mt. Washington did not at any time blow from the east quarter. I think we are therefore justified in inferring the following generalizations.

1. In a majority of those cases in which an area of low barometer passes over New England attended by the usual system of circulating winds at the surface stations, this system of circulating winds does not extend to the height of 6,000 feet.

2. When the depression of the barometer is unusually great, this system of circulating winds extends to the greatest height.

3. When during the progress of an area of low pressure, a system of circulating winds reaches to the summit of Mt. Washington, the change of wind to the east quarter usually begins at the surface stations eleven hours sooner than it does on the summit of that mountain; and the change back from the east to the west quarter usually begins at the base of the mountain five hours sooner than on the summit.

Abnormal storm paths.

In the hope of obtaining some information respecting the causes which determine the movement of areas of low barometer from place to place, I selected from the published volumes of the Signal Service observations those cases in which storm paths deviated most from their average course, and the results are shown in the two following tables, one containing those cases in which the direction of storm paths was most northerly, and the other containing those cases in which their direction was most southerly. Table II contains various particulars respecting eight storms whose course was nearly from south to north. Column 1st shows the number of the storm; column 2d shows the number of the observation; column 3d the date

of the observation; and column 4th the station at which the observed height of the barometer was least. This station was not generally at the center of the low area, but is presumed to have been not far distant from the center; column 5th shows the height of the barometer at the station named in column 4th; column 6th shows how much the barometer at the given date was below its mean height for that month as deduced from the observations of six years; column 7th shows how much the thermometer on the north side of the low area was depressed below its mean height for the hour of observation; column 8th shows how much the thermometer on the south side of the low area rose above its mean height for the hour of observation; column 9th shows the average humidity of the winds on the north side of the low area; column 10th the average humidity on the south side of the low area; column 11th shows the direction and velocity of the highest wind reported at any station on the north or west side of the low area; column 12th the direction and velocity of the highest wind reported at any station on the south or east side of the low area; column 13th shows the total rain-fall at all the stations east of the Rocky Mountains during the preceding eight hours; column 14th shows the total rain-fall at all the stations included within the same low area; and column 15th shows the direction of the center of the rain area from the center of low pressure for a time preceding the date of observation by four hours. When the center of low pressure is near the boundary of the United States it is generally impossible to determine from the observations where is the center of the rain area; and in such cases a blank is left in column 14th. When the center of the rain area coincided sensibly with the center of low pressure the syllable *cent.* is inserted. Table III contains similar particulars respecting six storms whose course was nearly from north to south. The last case in each of the tables was taken from the International series of observations in which the observations are given for only one hour of each day, and the rain-fall is the amount reported for the preceding twenty-four hours.

On comparing these two tables we find important differences in several particulars. In each case of Table II, with the exception of the last, the barometer became more depressed as the storm moved northward, and at the last observation of each case the average depression of the barometer below the mean was 0·26 inch greater than at the first observation. In each case of Table III the depression of the barometer increased for 16 hours or more, and then decreased, with the exception perhaps of the last case where the storm is only followed to Dodge City. In the other cases, the average depression of the barometer at the last observation was somewhat less than at the first

No. of storm.	No. of Obs.	Date.	Lowest Barometer.		Below mean.	Temp. N. wind.	Temp. S. wind.	Hum. N. wind.	Hum. S. wind.	Highest Wind. North'ly.	Highest Wind. South'ly.	Rain Fall. Total.	Rain Fall. In Low.	Which side.
		1872. Dec.	in.	in.	— °	+ °						in.	in.	
I.	1	19.1	Indianola.	29·70	·40	25	13	77	98	N. 12	S. 14	3·01	2·94	N.E.
	2	19.2	Nashville.	·79	·40	21	16	81	87	N.W. 17	S. 24	5·77	5·77	N.E.
	3	19.3	Louisville.	·62	·53	15	11	84	88	N. 20	S.E. 20	6·70	6·70	N.E.
	4	20.1	Buffalo.	·43	·56	19	12	80	89	N.W. 16	S.E. 24	14·37	14·37	N.E.
	5	20.2	Montreal.	·50	·58	12	8	79	88	N.W. 24	S.E. 18	5·28	5·28	
		1873. Jan.												
II.	6	1.3	Indianola.	·43	·70	8	12	81	87	N.E. 8	S.E. 16	0·64	0·54	N.N.E.
	7	2.1	St. Louis.	·53	·64	4	15	89	88	N.E. 11	S.E. 15	6·29	6·15	N.N.E.
	8	2.2	Milwaukee.	·23	·85	1	16	87	90	N.W. 29	S.E. 24	9·12	9·12	Cent.
	9	2.3	Milwaukee.	·07	1·01	2	11	82	90	N.W. 20	S. 20	6·28	6·28	
	10	3.1	Marquette.	·09	·98	3	19	82	90	N.W. 35	S. 20	7·84	7·37	
		Apr.												
III.	11	7.2	Indianola.	·66	·35	17	5	68	71	N. 25	S. 19	3·20	3·20	N.N.E.
	12	7.3	Memphis.	·68	·32	10	21	82	75	N. 28	S.E. 16	3·45	3·45	N.N.E.
	13	8.1	Cairo.	·64	·35	21	14	75	80	N. 34	S.E. 20	8·70	8·69	N.E.
	14	8.2	Louisville.	·52	·45	18	19	89	80	N.E. 32	S. 35	8·54	8·54	N.E.
	15	8.3	Chicago.	·54	·42	7	18	83	82	N. 26	E. 33	4·48	4·48	Cent.
	16	9.1	Escanaba.	·42	·55	17	15	85	85	N. 16	S.E. 32	3·75	3·75	
	17	9.2	Marquette.	·42	·58	12	14	67	83	N.W. 23	S. 32	3·98	3·98	
		Oct.												
IV.	18	19.2	Charleston.	·64	·45	4	3	66	91	N.W. 12	E. 13	6·84	6·84	N.
	19	19.3	Norfolk.	·52	·58	10	8	77	94	N. 16	S.E. 24	9·82	9·82	N.
	20	20.1	Cape May.	·45	·62	19	16	82	95	N. 28	S.E. 32	17·65	17·65	N.
	21	20.2	Phila'phia.	·26	·82	14	11	56	93	N. 36	E. 42	12·27	12·27	N.
	22	20.3	Pittsburgh.	·38	·63	15	13	78	95	N. 28	S.E. 32	9·86	9·86	N.
	23	21.1	Erie.	·28	·69	13	11	78	83	N. 32	S. 24	5·90	5·90	N.W.
	24	21.2	Alpena.	·36	·58	14	9	65	78	N. 20	S. 28	3·01	3·01	N.W.
		1874. Jan.												
V.	25	5.3	Jacks'ville.	·95	·25	8	12	81	91	N.E. 20	E. 24	3·05	3·04	
	26	6.1	Montgom'y.	·90	·32	8	17	86	95	N.E. 18	E. 24	8·82	8·78	N.N.E.
	27	6.2	Augusta.	·74	·46	4	11	79	89	N. 16	S. 16	12·48	12·48	N.
	28	6.3	Augusta.	·61	·59	0	16	83	89	N. 24	S.E. 24	8·35	8·35	N.
	29	7.1	Lynchburg.	·57	·61	1	26	82	95	N.E 18	S.E. 24	11·81	11·81	N.N.E.
	30	7.2	Pittsburg.	·46	·67	7	22	88	93	N.W. 18	S.E. 18	9·48	9·48	N.E.
	31	7.3	Cleveland.	·54	·56	1	26	85	92	N. 12	S. 12	6·27	6·27	E.N.E.
	32	8.1	Oswego.	·46	·60	3	33	81	97	N.W. 12	S. 20	5·65	5·65	E.N.E.
	33	8.2	Ottawa.	·31	·67	2	29	72	87	N.W. 18	S. 20	1·68	1·68	
		Mar.												
VI.	34	6.1	Ft. Gibson.	·40	·56	17	10	86	85	N. 12	S.E. 24	10·93	10·93	N.E.
	35	6.2	Keokuk.	·23	·78	9	16	74	83	N. 30	S. 29	5·16	5·06	E.N.E.
	36	6.3	Dubuque.	·16	·86	5	21	77	87	N.W. 35	S.E. 27	5·76	5·22	N.E.
	37	7.1	Milwaukee.	·17	·86	13	3	7	89	N.W. 32	S. 25	8·82	8·77	
	38	7.2	Alpena.	·24	·76	11	9	75	84	N.W. 28	E. 20	3·92	2·32	
		1877. Feb.												
VII.	39	28.2	Indianola.	·90	·23	15	8	52	82	N. 12	E. 13	1·12	1·11	N.
	40	28.3	Galveston.	·88	·22	6	7	49	93	N.E. 12	E. 12	2·31	2·31	N.
		Mar.												
	41	1.1	Shreveport.	·73	·33	6	4	68	95	N.W. 12	S.E. 14	4·15	4·01	Cent.
	42	1.2	Memphis.	·56	·52	8	2	69	93	N.E. 10	S. 20	9·43	9·43	N.E.
	43	1.3	Cairo.	·42	·65	4	9	85	88	N.E. 16	S. 28	5·17	5·17	E.
	44	2.1	Chicago.	·17	·85	4	16	84	87	N.W. 16	S.E. 24	13·62	11·45	N.E.
	45	2.2	Saugeen.	·12	·87	3	12	78	90	N.W. 24	S. 40	18·52	18·52	
		Dec.												
VIII.	46	21.1	Concho.	·56	·44	7	14	82	89	N. 12	S.E. 24	12·00	12·00	N.E.
	47	22.1	Dodge City.	·37	·43	7	35	88	93	N.W. 32	S.E. 24	11·34	11·34	E.N.E.
	48	23.1	Bismark.	·55	·40	8	37	82	93	W. 12	S.E. 20	12·43	12·43	E.N.E.
Means.						9.5	14·7	78	88	20.8	23·0		6·89	

TABLE III.—*Storms Moving Southward.*

No. of Storm.	No. of Obs.	Date.	Lowest Barometer.		Below mean.	Temp.		Hum.		Highest Wind.		Rain Fall.		
						N. wind.	S. wind.	N. wind.	S. wind.	North'ly.	South'ly.	Total.	In Low.	Which side.
		1877. Jan.		in.	in.	— °	+ °					in.	in.	
I.	1	3.3	Pembina.	29·91	·20		2		70	N.W. 16	S. 14	0·82	0·00	
	2	4.1	Ft. Sully.	·83	·27	3	5	82	79	N.W. 28	S. 16	0·99	0·22	
	3	4.2	Ft. Sully.	·67	·43	0	5	74	77	N.W. 28	S. 13	1·11	0·63	E.
	4	4.3	Omaha.	·80	·33	3	9	86	72	N. 25	S. 10	0·54	0·48	E.
	5	5.1	Ft. Gibson.	·80	·36	2	3	86	78	N.W. 34	S. 7	0·49	0·30	S.S.E.
	6	5.2	N. Orleans.	·90	·28	6	0	76	68	N.W. 20		0·96	0·90	S.E.
II.	7	9.3	Virginia C.	·46	·19		7		80		S. 18	0·70	0·59	E.
	8	10.1	Virginia C.	·31	·34	14	12	75	81		S.E. 24	0·80	0·72	E.S.E.
	9	10.2	N. Platte.	·07	·78	20	17	73	81	N.E. 24	S.E. 18	0·97	0·77	E.
	10	10.3	N. Platte.	·03	·82	22	10	76	76	N.E. 24	S.E. 12	1·24	0·41	Cent.
	11	11.1	Ft. Gibson.	·64	·52	35	22	83	81	N.W. 25	S.E. 12	2·03	1·74	E.N.E.
	12	11.2	Denison.	·76	·45	29	19	77	74	N.E. 32	S. 20	6·88	0·20	N.
	13	11.3	Corsicana.	·95	·25	35	20	71	84	N.E. 34	S. 12	2·98	0·76	N.
	14	12.1	Indianola.	30·05	·09	21	24	82	91	N. 20	S. 10	1·16	0·99	N.N.E.
		Feb.												
III.	15	17.3	Ft. Garry.	29·79	·39		20		77		S. 12	0·34	0·00	
	16	18.1	B'kenridge.	·73	·41		18	78	78	N.W. 30	S. 16	0·42	0·00	
	17	18.2	Milwaukee.	·55	·52	3	16	63	64	N.W. 26	S.E. 20	1·55	0·99	E.S.E
	18	18.3	Toledo.	·58	·50	6	14	75	66	N. 26	S. 15	1·02	0·98	E.N.E.
	19	19.1	Pittsburgh.	·59	·50	11	5	76	62	N.E. 24	S. 4	0·42	0·27	N.E.
	20	19.2	Norfolk.	·63	·47	11		64		N.W. 20	S.W. 14	0·46	0·39	N.E.
	21	19.3	Wilm'gton.	·76	·37	7		63		N. 32		0·53	0·43	
	22	20.1	Savannah.	·88	·28	6		72		N.E. 30		1·42	0·39	
IV.	23	20.3	Pembina.	·64	·49		26		77		S. 10	0·03	0·00	
	24	21.1	B'kenridge.	·54	·60		27		75		S. 12	0·00	0·00	
	25	21.2	Duluth.	·35	·72		43	63		N.W. 45	S. 25	0·15	0·15	
	26	21.3	St. Paul.	·38	·70		23	76		N.W. 27	S. 21	0·19	0·19	
	27	22.1	LaCrosse.	·46	·65		28	79	63	N.W. 30	S. 21	0·18	0·18	
	28	22.2	Davenport.	·53	·60	0	21	61	56	N. 30	S. 13	0·79	0·78	S.
	29	22.3	St. Louis.	·58	·53	4	20	71	57	N. 24	S. 8	1·80	1·80	S.S.E.
		Mar.												
V.	30	21.3	N. Platte.	·19	·45	15	24	78	58	W. 28	S. 14	9·44	0·00	
	31	22.1	Omaha.	·46	·55	19	21	76	63	N.W. 20	S.E. 14	8·59	0·13	
	32	22.2	Dodge City.	·07	·56	13	21	58	59	N. 44	S. 26	5·21	0·27	N.E.
	33	22.3	Ft. Gibson.	·66	·30	19	19	80	57	N.E. 40	S.E. 16	1·30	0·19	N.W.
	34	23.1	Ft. Gibson.	·73	·23	19	17	79	73	N. 24	S.E. 8	3·81	1·11	N.
	35	23.2	Corsicana.	·67	·33	14	15	62	45	N.E. 30	S.E. 17	4·81	1·31	N.
	36	23.3	Indianola.	·83	·25	10	15	73	69	N. 22	S. 11	3·70	2·93	N.
		1878. Feb.												
VI.	37	18.1	Virginia C.	·44	·20	6	18		75		S. 16	4·82	0·20	
	38	19.1	B'kenridge.	·38	·76	8	21	71	72	N. 12	S.E. 17	1·56	0·04	
	39	20.1	Dodge City.	·06	·74	0	28	86	76	N.W. 19	S. 18	3·46	2·89	E.
Means.						12.0	17·1	74	71	27·1	14·8		0·57	

observation, and less than half of what it was at an intermediate date. In table II the average temperature of the winds on the north side of the low area was 9·5 degrees below the mean for that time and place; and the average temperature of the winds on the south side of the low area was 14·7 degrees above the mean for that time and place. In table III the average temperature of the winds on the north side of the low area was 12 degrees below the mean, and on the south side was 17 degrees above the mean. The blanks in columns seven and eight of table III result from the center of least pressure being near the boundary of the United States, so that the signal service stations do not furnish the required data. In both tables the average humidity of the north winds was nearly the same, but the humidity of the south winds was very much the greatest in table II. In table II the average velocity of the south winds was ten per cent greater than that of the north winds. In table III the average velocity of the north winds was about double that of the south winds. In table II the average rain-fall in eight hours within the low areas was 6·89 inches; in table III the average rain-fall was 0·57 inch, and in a majority of the cases in this table the average rain-fall in eight hours was only 0·14 inch.

The most remarkable circumstance which characterizes these two classes of storms is the difference in the amount of rain-fall. In the cases shown in table II the rain-fall was enormously great, and this appears to be the general characteristic of those storms which originate near the Gulf of Mexico. In my seventh paper, I gave a list of all the cases contained in the volumes of the Signal Service observations which had then been published, showing a total rain-fall of eight inches in eight hours at all of the stations. More than two-thirds of all these storms originated on or near the Gulf of Mexico, and a majority of the remaining cases occurred in summer. One reason why these storms are attended by a great fall of rain appears to be that the south wind is charged with a large amount of vapor from a warm sea. From table II it appears that this south wind is warm, moist, and pushes northward with great force.

The principal object which I had in view in preparing these tables was to discover, if possible, the reason why these storms pursued so unusual a path. The average course of the eight storms in table II was only 20 degrees east of north. One of them moved almost exactly north, and another deviated sensibly to the west of north. Can any reason be assigned for this unusual course? I have endeavored to determine whether there was any connection between the course of the storm and the rain-fall which accompanied it. Plate I of my 7th Paper shows the curves of equal rain-fall for the eight hours preceding

7^h 35^m, Oct. 20, 1873, and corresponds to No. 20, table II of the present Article. At that date the center of low pressure was moving almost directly towards the center of the rain-area. Plate I accompanying the present Paper, shows the isobars for Oct. 21.1, 1873, and the dotted line shows the area over which the rain-fall for the preceding eight hours amounted to at least one-fifth of an inch. The rain-fall at Cleveland was ·75 inch; Alpena ·58 inch; Rochester ·49 inch, and Saugeen ·49 inch. It will be perceived that during these eight hours the storm center had been moving almost exactly towards the center of gravity of this rain-area. There was also a rain-area extending along the New England coast from Boston to Eastport which did not appear to exert any appreciable influence upon the progress of the storm. I have made a similar comparison for each date in table II and find that in each case the storm center was moving nearly towards the center of the rain-area. In more than half of the cases the storm appeared to be moving exactly towards the center of the rain-area. In four of the cases the rain center appeared to be a little westward of the storm path, and in twelve cases it appeared to be a little eastward, but in only two or three cases did it deviate as much as 45° from the direction in which the storm center was moving. This coincidence seems to favor the conclusion that in a great storm the condensation of the aqueous vapor is an efficient cause which controls the movement of the winds.

Table III shows results very different from table II. In six of these cases no rain was reported at any station within the area of low pressure during the preceding eight hours; in 23 of the cases the total rain-fall during the preceding eight hours at all the stations within the low area was less than half an inch; and in only five of the cases did the total rain-fall in eight hours exceed one inch, and in each of these five cases there appears to have been a special reason for the greater rain-fall. In No. 11 the rain center was about 600 miles northeast of the center of low pressure, and the succeeding observation shows that there was another low center in Canada which mainly controlled the movement of the winds throughout this rain-area. In No. 29 the character of storm No. IV had already changed, and the subsequent course of the storm was nearly east. In Nos. 34, 35 and 36 the greater rain-fall is partly explained by the proximity of the low center to the Gulf of Mexico. In No. 39 the rain-fall is given for a period of 24 hours. Thus we see that an area of low pressure may be formed with very little rain, and apparently with none at all. Moreover in these cases the storm center did not generally follow the rain-area but moved away from it. Plate II accompanying this paper shows the isobars for Jan. 4, 1877, at 4^h 35^m P. M., indicating a low center near Ft. Sully.

The rain-fall reported for the preceding 8 hours was as follows: 1. Milwaukee, 0·14 inch; Marquette, 0·10; Grand Haven, 0·08; Escanaba, 0·05; Port Stanley, 0·02; Detroit, 0·01; and Toledo, 0·01, amounting together to 0·41 inch. Around the first four of these places I have drawn a dotted line, which is designed to represent the area over which the rain-fall was at least 0·05 inch. 2. A rain-fall of 0·09 inch was reported at Bismark and of 0·05 at Ft. Sully. I have also drawn around these places a dotted line representing the area of 0·05 inch rain-fall. 3. A rain-fall of 0·08 inch was reported at North Platte. Thus we see that the principal rain-fall was about 600 miles east of the low center, and the low center traveled southward apparently uninfluenced by this rain-fall. There was a smaller rain area which was nearly concentric with the area of low pressure, and there was a very slight fall of rain on the south side of the low center. I have made a similar comparison for each of the dates of observation, and find the following results: In seven of these cases the principal rain center was about 350 miles north of the center of the low pressure; in four of the cases it was on the northeast side, and at a distance of about 500 miles; in eight of the cases it was on the east side, distant about 600 miles; in one case it was on the northwest side; in one case it was on the southeast side; and in only three cases was the center of the rain-area nearly south of the center of low pressure, viz: Nos. 5, 28 and 29. In the last case the storm, instead of following the rain towards the south, immediately changed its course and moved off towards the east. Thus, out of thirty-nine cases we find only one case in which the storm seemed to follow the rain-area, but in half of the cases the storm traveled almost directly away from the rain-area, and in nearly all of the remaining cases the course of the storm was nearly at right angles to the direction of the rain-area. These facts seem to show that in these cases the rain-fall exerted no appreciable influence upon the course of the storm, and therefore no appreciable influence upon the fall of the barometer. This conclusion is confirmed by the observation of the clouds. In all the cases given in table III, the average cloudiness on the south side of the low area was less than one-half; and in several cases the sky was *entirely cloudless* at every station on the south side of the low area. This was true for Nos. 15, 16, 17, 23, 24, 30, 31 and 32.

This evidence appears to me to show that heavy and extensive precipitation does not invariably precede the first formation of depression areas and accompany their expansion, as has been claimed. These depression areas increased in intensity when the rain-fall was nearly zero, and while the sky on the south side was not generally overcast with clouds, but in several cases was almost entirely clear. In

the United States, depression areas do not generally begin with extensive precipitation, but the rain-fall is a concomitant after the system of circulating winds has become pretty well established. The depression of the barometer is the result of a system of circulating winds, and the most frequent cause producing such a system appears to be two or more areas of high pressure at a considerable distance, (frequently 1,400 miles) from each other. Differences of temperature and of humidity are also important agents in producing and sustaining such a system of winds. When a system of circulating winds has been formed over a large extent of country, there almost invariably results a fall of rain; and if the rain-fall is abundant, and extends over a large area, it becomes a very important agent in modifying the direction and force of the winds.

The principal question still remains undecided, why did the storms in table II pursue a course so nearly from south to north, and those in table III, a course nearly from north to south? The average course of storm paths appears to be determined mainly by the average system of circulation of the atmosphere near the earth's surface, and occasional departures of storm paths from this average track appear to be mainly due to causes which render the general movement of the atmosphere at such times different from the average movement. In table II it is seen that the average velocity of the winds on the south side of the storm's center was somewhat greater than on the north side. This seems to indicate that at these times a wind from the south or southeast pressed towards the storm-area with unusual force. This wind extended to a height greater than 6,000 feet, as is shown by the observations on Mt. Washington whenever a storm center came into the neighborhood of that station. The following observations show the direction and force of the wind on that mountain during the progress of storm No. IV. Oct. 20.1, wind S.E. 75 miles; Oct. 20.2, wind S.E. 78 miles; Oct. 20.3, wind S. E. 50 miles; Oct. 21.1, wind S. E. 55 miles; Oct. 21.2, wind S.E. 38 miles. The observations also show that this south current extended to the height of the upper clouds. This is seen from Plate I, where the arrows indicate (*not* the direction of the surface winds), but the direction of the upper clouds, according to the reports of the Signal Service observations for Oct. 21.1, 1873. These arrows conform in a remarkable degree to the direction of the surface winds, and seem to indicate that the system of circulating winds which prevailed at the surface of the earth, extended to a height greater than 6,000 feet into the region of the upper clouds; a height which is very uncertain and difficult to estimate. The only important exception to the rule here

stated is the observation at Davenport, which appears suspicious, since at the afternoon observation of the same day, the upper clouds were reported from the northwest. Generally throughout the eastern half of these low areas the lower clouds were dense and unbroken, so that there was no opportunity to obtain observations of the direction of the upper clouds, but in several cases observations were made which indicated a circulation of the winds at the height of the upper clouds similar to that described for Oct. 21.1. This is seen in the observations of Nos. 8, 24, 29, 30, 35 and 36.

In table III the velocity of the wind on the north side of the low areas was nearly double that on the south side, and this northerly wind extended to a considerable height, as is shown by the observations on Pike's Peak. The following observations show the direction and force of the wind on that mountain during the progress of storm No. I. Jan. 3.3, wind north 30 miles; Jan. 4.1, wind north 42 miles; Jan. 4.2, wind north 32 miles; Jan. 4.3, wind north 38 miles; Jan. 5.1, wind northeast 20 miles; Jan. 5.2, wind north 36 miles. This northerly current extended to the height of the upper clouds. This is seen from Plate II, where the arrows indicate the direction of the upper clouds according to the reports of the Signal Service observers for Jan. 4.2, 1877. These arrows indicate a movement of the upper clouds from the west or northwest over nearly the whole of the United States from the Pacific Ocean to the Atlantic; and throughout the western half of this region the movement was mainly from the northwest. At no station were the upper clouds reported as moving from the southeast, east or northeast, and at only one station were they reported from the south. At the thirty-nine dates enumerated in table III, there were only five cases in which the upper clouds were reported from the east at any station which could be regarded as included within the system of circulating winds here considered; there were five cases in which the clouds were reported from the southeast, and thirty-one cases in which the clouds were reported as moving from the south, and about half of these cases occurred Feb. 22d, when storm No. IV was losing its previous character and preparing to change its course from south to east. These facts seem to indicate that the surface winds which prevailed on the south and east sides of the low areas enumerated in table III, were not only dry and feeble, but extended to a less height than the southerly winds which attended the storms enumerated in table II.

These facts seem to indicate that at the time of the observations in table II, there was an unusually strong current from the south or southeast, which reached to a height of over 10,000 feet, and swept over a considerable portion of the United States;

while at the time of the observations in table III, there was an unusually strong current from the north or northwest, which also reached to a height of more than 10,000 feet, and swept over the United States from the Pacific Ocean to the Atlantic.

The cases enumerated in table III are remarkable on account of the long continuance of the movement of storm centers from north to south, but the published volumes of the Signal Service observations show many other cases in which storms pursued a similar course for twenty-four hours or more.

In preparing the materials for this article, I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

ART. II.—*Silurian Formation in Central Virginia;* by J. L. CAMPBELL, Washington and Lee University.

Limits.—What is known as the "Great Valley of Virginia" occupies a belt of country extending entirely across the State from the Tennessee line on the southwest to the Potomac on the northeast—including Jefferson and part of Berkeley County, now a portion of West Virginia. It has mountain boundaries throughout its whole extent. On its southeastern margin it is separated from what is called "Piedmont Virginia," by the Blue Ridge and its southwest prolongations, Poplar-Camp and Iron Mountains. On the northwest side we find a somewhat irregular line of broken ridges bearing different names at different points. Through several of the southwest valley counties it is called "Walker's Mountain." In Botetourt, Rockbridge and Augusta, it is called "North Mountain," while through the remainder of the distance to the Potomac it is called "Little North Mountain." The length of the Valley, from the Tennessee line to the Potomac, is about three hundred and thirty miles. Near its southwest extremity, in Washington County, it is about twelve or fifteen miles wide, and becoming gradually wider it extends towards the northeast. We find it in Rockbridge and Augusta varying in breadth from twenty to twenty-five miles. Its total area, embracing the contiguous mountain slopes on each side, is not much short of 6,000 square miles.

Its Topography.—With the exception of a limited belt occupied by the Massanutton range in its northeast parts, and some strips covered by outliers of North and Walker's Mountains, this extensive zone has for its surface one continuous outcropping of the Lower Silurian rocks. Before examining into the geological features of this interesting region, it will be well to take a bird's-eye view of its topography. (1.) It lies between two elevated mountain ranges—the Blue Ridge on the

southeast rising to heights ranging generally between 2000 and 4000 feet above tide-level; and the North Mountain range on the northwest, almost equally high at many points. (2.) The axial line of the Blue Ridge (which consists chiefly of Archæan rocks) has but few gaps through which streams of water can pass. Not a single outlet of any considerable size is found for the waters of the valley through this ridge anywhere between Harper's Ferry on the Potomac and Balcony Falls on the James—a distance of one hundred and fifty miles. The only other water-gaps are the one through which the Roanoke (afterwards the Staunton) River passes towards the southeast, and the narrow, rugged ravines by which the waters of New River (Kanawha) and some of its tributaries run down from the Plateau formed by the bifurcation of the Blue Ridge towards its southwest extremity. But along the northwest side of the axial ridge, throughout the greater part of its extent, we find a large number of short broken ridges and irregular peaks, forming sometimes double, and often triple, lines nearly parallel with the main mountain, and indicating by their position and structure that they were once continuous ridges that have since been fractured and cut into deep gorges, through which small streams of water now run down into the limestone valley below. These broken ridges consist of Primordial rocks. The mountains on the northwest are far less regular and continuous than the main Blue Ridge, and are traversed by numerous water-gaps. Here the Upper Silurian (Medina) Sandstones constitute the material of which most of the ridges are constructed, and the heavy beds are frequently arched or folded, and cut through by ravines of considerable extent and grandeur, like that through which New River makes its way towards the Ohio, or the beautiful arch at Clifton Forge, or the grand "Goshen Pass" between the Chesapeake and Ohio Railroad and Lexington.

(3.) Those who have not visited this section of the State must not imagine that the "valley" is one vast continuous plain like some of the western prairies. It is a land of "hill and dale, of water-brooks and fountains of water." Its limestone and cherty ridges are frequently of such dimensions that in many parts of the world they would be called "mountains;" and where they are cut by the bold and rapid streams that abound here, they present many steep and naked cliffs, sometimes more than two hundred feet in height above the water. Such natural sections present features of great interest to the geologist; and afford important aid in ascertaining the real structure and relative position of the several sub-divisions of this, the most remote age of paleozoic history.

(4.) Any good map of Virginia will show that this valley is

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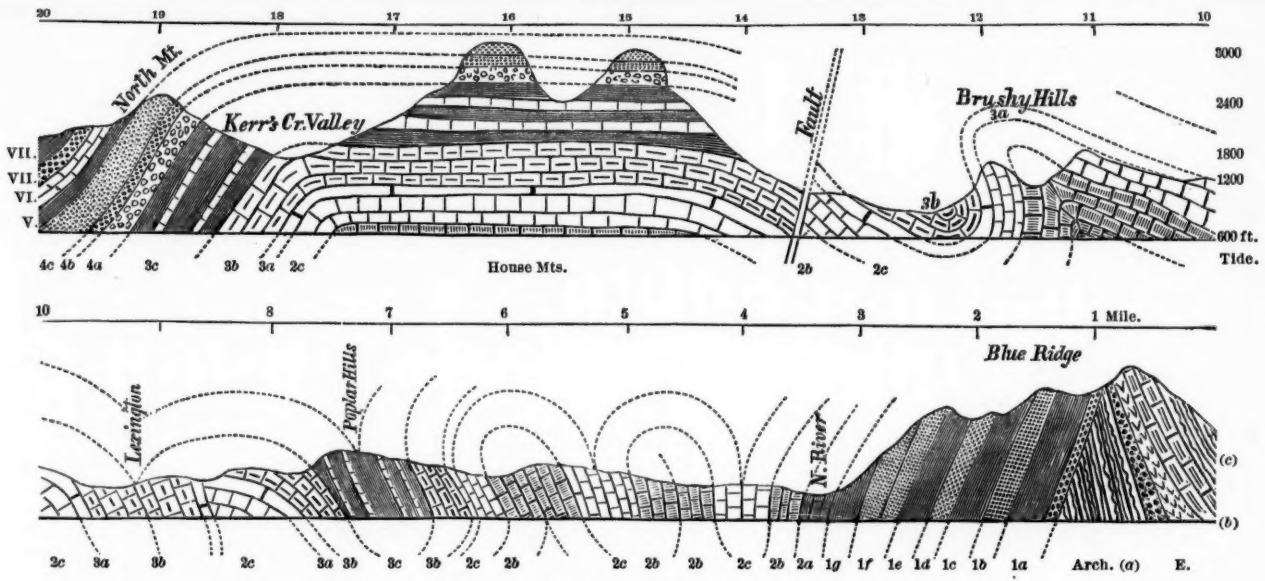
not single, whether viewed lengthwise or crosswise. From a few miles southwest of Winchester to a point nearly opposite Harrisonburg, it is divided into two subordinate valleys, by the Massanutton Mountains—a long belt of ridges of Upper Silurian and Devonian rocks that withstood the denuding agencies that uncovered so many hundreds of square miles of the Lower Silurian limestones. Less extensive ridges also interrupt the continuity on the northwest side; and some of them, like the House Mountain,* across which the accompanying section passes, present striking examples of mountains *left* in isolated positions by the sweeping away of the once adjacent rocky masses through the powerful denuding agencies of water and ice. That such agencies have operated in this region on an extensive scale will be considered more fully hereafter.

The cross divisions of the valley are marked by the water-sheds that determine its drainage. Southwest of Wythe County we find the waters carried off by the Holston into the Tennessee River. Wythe, Pulaski and part of Montgomery, are drained by New River, which runs down from the Blue Ridge plateau, crosses towards the northwest and makes its way to the Ohio. Thus we have "New River Valley." A small portion of Montgomery and nearly all of Roanoke County, are drained by the Roanoke River—one of the three rivers that have cut water-gaps through the Blue Ridge in a southeasterly direction. Next to this "Roanoke Valley" comes the upper "James River Valley," occupied by Botetourt and Rockbridge. Extending from the water-shed (crossing near the line between Rockbridge and Augusta) to the Potomac, we find the extensive "Shenandoah Valley."

(5.) *Elevations.*—At Harper's Ferry, where the Potomac leaves the Great Valley, the height above tide-level is only about two hundred and forty feet; but when we reach the head waters of the Shenandoah, we have arrived at a water-shed having an average height of nearly 1800 feet. Then, in passing on to the south corner of Rockbridge, we come to the "pass" of the James, at Balcony Falls, having an elevation of about 700 feet. The Roanoke Valley has about the same average elevation as that of the James Valley, 1200 feet; but on rising to the margin of New River Valley, near Christiansburg, in Montgomery County, we are about 2000 feet high; and on the southwest margin, at Mount Airy—the summit of the A. M. & O. Railroad—2600 feet. Many points on the Blue Ridge are not higher than this highest part of the great limestone valley. At the Tennessee line the height is less than 1700 feet.

* This is often spoken of as if it were a single mountain—and so it appears to be as seen from Lexington—while, in reality, there are two short parallel ridges nearly a mile apart, cut off abruptly at both ends.



SECTION OF SILURIAN FORMATION, ROCKBRIDGE CO., VA.—From S. E. to N. W. 20 Miles.

DESCRIPTION OF SECTION.—1. The leading divisions of strata are denoted by the numbers 1, 2, 3, 4; V, VI, VII, VIII, corresponding with the Pennsylvania series (Rogers). 2. Sub-divisions are indicated by letters attached to the numbers, as 1*a*, 1*b*, 2*a*, etc. 3. On the right-hand end below (the proper place to begin the examination), the Archæan rocks are marked, "Arch. (*a*), (*b*), (*c*);" while an eruptive mass protruding near the crest of the Blue Ridge is marked, E. 4. The beds of sandstone are *dotted*,—coarsely when more or less conglomerate; beds of shale have closely *ruled* lines; limestone strata are *blocked*, some having *longitudinal* and some *cross* rulings, to distinguish *epochs*. 5. The feldspathic rocks east of Blue Ridge have double longitudinal lines. 6. Heights above tide level are indicated on the right of the upper division of the section.

Here, then, we have a plateau, rather than a valley, with an average elevation above the sea of about 1200 or 1300 feet. This is much above the average elevation of the Mississippi Valley. It is in reality a part of the great belt of uplift that constitutes the Appalachian Range, but erosive agencies have stripped it of the greater part of its mountain-making masses. The Blue Ridge, which now forms its southeast border, was once the shore-line of the great primal ocean that covered the Mississippi Valley (including "Appalachia") during the remote ages of geological history.

At present the streams of water in the valley tend towards the southeast margin all the way from the Potomac to Salem, in Roanoke County. This is most strikingly the case in the basins drained by the Roanoke and the James Rivers, thus indicating less elevation on that side than on the other. I think we shall learn hereafter that this is most probably the result of difference in the amount of denudation on the two sides.

This brief summary of the most conspicuous physical features of the Great Valley and its surroundings is deemed sufficient to give the reader a tolerably distinct, though very general view of the *present* surface formed by the outcropping of the most extensive exposure of Lower Silurian rocks in Virginia. There are other less extensive exposures of the same rocks forming subordinate limestone valleys, but they must be left out of our present discussion.

Geology.—My purpose is to give in the first place a section extending from the Blue Ridge to the North Mountain, embracing some of the Archæan rocks at one extremity, and of the Devonian at the other. The discussion of this, with its divisions and sub-divisions, and some leading peculiarities of each, will, I think, illustrate the geology of this middle part of the State in a manner, and to an extent, not hitherto attempted by any one.

I am indebted to the partial survey of Virginia, made under the direction of the venerable and distinguished geologist, Professor W. B. Rogers, for guidance and aid in my own investigations and for many of the facts contained in this communication. The line of section here given has been carefully explored and re-explored throughout its whole extent, several times. It crosses a portion of the valley not heretofore represented in section, so far as I know; and while it may be regarded, to a certain extent, as typical of this region of the State for some miles on each side of its line, it presents some peculiarities worthy of special notice. These will be discussed in future. For the present a general description must suffice.

The southeast extremity is on the slope of the Blue Ridge beyond Robinson's Gap, and extends one mile past the line

between Rockbridge and Amherst Counties; while the northwest reaches about a mile beyond the crest of the North Mountain to the valley of the Rockbridge Alum Springs, where it cuts the Devonian shales from which the waters of those springs flow. A subordinate ridge of Medina sandstones, however, rises in the valley between the end of the section and the Springs.

The first general division includes the metamorphic and eruptive rocks of the main Blue Ridge. The other general divisions are those adopted by Professor Rogers in his survey of the State (1836–41). Only Nos. I to VII are included. The sub-divisions into which each of these is here divided are my own, and may be regarded as representative (with local modifications), not only of the limestones of the Great Valley, but also of the shales and sandstones of the bordering mountains and outlying ridges on both sides. They are marked, *a*, *b*, *c*, etc., in ascending order, and will be found to correspond with many of the subdivisions given by Professor Dana in his Manual of Geology (ed. 1875).

There is no natural section or gap through the metamorphic and eruptive rocks at this point on the Blue Ridge, but the outcrop is quite distinct, except that of a mass of syenite (E) protruded among the stratified rocks. The crest of the ridge is marked by a heavy bed of syenitic gneiss (or stratified syenite), (*b*) which might readily be taken for an igneous rock—so greatly has it been metamorphosed. This, with the thinner beds of like composition, and the interstratified slates (*c*) all dip steeply to the S.E.—or rather S.S.E. Beneath the mass of syenite we find first gneissoid rocks with considerable quantities of epidote; and under these, slates and sandstones, all dipping conformably with those above. These are *a* of the metamorphic group on the section.

Against the upturned edges of these metamorphic strata we find the lowest of the Primordial beds, resting *unconformably*, and dipping in the opposite direction. Here begins No. I of Professor Rogers's divisions. It might be subdivided into very many alternations of sandstones and shales, but I have preferred to limit the number to *seven*, that are quite constant in their general features for many miles along the N.W. face of the range. At the grand natural section at Balcony Falls, where the James River passes through the mountain, about fifteen miles S.W. of my line, there is a very interesting exposure of all the divisions here given—similar in relative position, similar in lithological and fossil characters, and having the same general dip.

No. I.—The group, No. I, *a*, as a general rule, has a layer of feldspathic and siliceous conglomerate near the bottom, then

dark shales alternating with sandstones more or less conglomerate. The shales, however, predominate. Next comes a bed (*b*) of very hard sandstone—quartzite; the upper and lower layers of which are more brittle than the main mass lying between them. This is succeeded by a much thicker mass of brown, purple and yellow shales (*c*), with thin beds of brittle sandstones. This mass is extensively disintegrated at the James River pass on both sides, where its thickness is about 550 feet, including a considerable bed of sandstone which at that point seems to separate it into two somewhat distinct divisions. But at Robinson's Gap, and other places, this bed of interstratified sandstone either disappears or becomes very thin. The bed (*d*) is very constant, very hard, and has a jointed structure so deeply marked and so extensive, that the cleavage planes thus developed have sometimes been mistaken for planes of stratification dipping S.E. The division (*e*) consists of shales of much lighter color than those found lower in the series. Some of the beds are decidedly kaolin in character, with numerous scales of mica disseminated through them. Up to this point we find only very faint indications of fossil remains of either plant or animal. A few scolithus borings (in *b* and *d*) are found, but they are rare, in comparison with what are found in (*f*). This (*f*) is the "typical sandstone" of the range, and constitutes the frame-work of what was once a continuous ridge, but is now crossed by numerous gorges, which have divided it into many short ridges and irregular knobs and peaks. It is a hard sandstone of white and light gray color, and jointed structure; and along this and other parts of its range it "exhibts vague, fucoidal and zoophytic impressions on the surface of bedding, together with innumerable markings at right angles to the stratification, penetrating in straight lines to great depths in the rock, and from their frequency and parallelism determining its cleavage in nearly parallel planes. These markings are of a flattened [many of them] cylindrical form, from $\frac{1}{8}$th to $\frac{1}{16}$th of an inch broad, giving the surface of the fractured rock a ribbed appearance, and resembling perforations made in sand which have been subsequently filled up, without destroying the original impression." Such is Professor W. B. Rogers's description of the characters given to this heavy bed of rock by the *Scolithus linearis*. These fossils are so numerous that I recently counted at Balcony Falls about 150 of their extremities projecting on one square foot of surface. This may very properly be called the "Scolithus bed" of this Primordial formation. The thinner beds at the top and bottom disintegrate rapidly. Between this and the first limestone of the valley is a thick mass of ferruginous shales generally much disintegrated and covered with the

debris of sandstone from the adjacent ridges just described. This is (*g*) on the section. It sometimes rises to a considerable height on the slope of the "scolithus bed," especially where the dip is low; and in a few cases, as at Irish Creek, I have found it reaching the crest of the ridge. It is one of the richest repositories of iron ore in Virginia—especially brown hematite—and has valuable beds of manganese, one of which, near Waynesboro', in Augusta county, is at present extensively worked. The ores o f the Shenandoah Iron Works of Page county are obtained from this bed of shale. Although it abounds in iron ores, yet it has the peculiar feature of containing a layer of clay so white as to be called "chalk" by the people of the region.

This brings us to the border of the limestones of the valley, and the plane of division between No. I and No. II. Thus we have passed over the Primordial Period. If it has here representatives of both the Acadian and Potsdam epochs (which I doubt) the lowest shales and sandstones must represent the former, and the upper shales and sandstones the latter. For the present, at least, I shall regard the whole as belonging to the Potsdam. The total thickness varies considerably as we ascend the ridges. This is especially conspicuous in the beds of shale, and causes such a decided variation in the dip of the sandstones as to make them present the appearance in many places of segments of broken arches; the dip varying as it does here and at Balcony Falls from 65° at the base to 30° near the upper margin, or outcrop of the beds. This peculiarity has been caused either by an original thinning out of the beds towards their margin before they were upheaved, or by a squeezing out of a portion of their material by the resistance and pressure of the more unyielding beds of sandstone above and below, at the period of upheaval.

The *thrust*, which was doubtless from the Blue Ridge towards the valley, seems to have been more powerful near the base than it was near the summit. Hence the steeper dip below, which has become reversed in the limestones for several miles from the foot of the mountain.

No. II.—The first natural subdivision (*a*) of the valley limestones may with propriety be called the "Hydraulic Formation," inasmuch as it abounds in hydraulic limestones throughout its whole length. It includes, however, several layers of very siliceous and argillaceous limestones separated from one another by beds of brown, bluish and purple shales, and some soft sandstones. The best bed of hydraulic stone is near the bottom of this division, and where it has been quarried for many years, near Balcony Falls, is only about twelve to fifteen feet thick, and dips steeply to the N.W. Where our section

crosses the strata of *a* they are nearly vertical. From this point to the Brushy Hills beyond Lexington, the strata (with one or two local and very limited exceptions), all dip towards the Blue Ridge; and, upon a superficial view of the case, might be supposed to extend beneath it. But examinations of the relative position of the sandstones and limestones at other points in the valley, together with lithological and fossil peculiarities that prove the more recent origin of the limestones, lead to the conclusion that they are *geologically* above the sandstones and shales already described. The several repetitions of the subdivisions of No. II, between the Poplar Hills and North River can be accounted for only upon the hypothesis of plications in the strata caused by pressure on the one side and resistance on the other. We conclude, therefore, that the hydraulic beds (*a*), as originally deposited on the ancient sea-bottom, underlie those of *b*, while these again were overlaid by the beds of *c*. Only occasional fucoid plants, and brachiopod mollusks have been seen in *a*. It seems to be the equivalent of the Calciferous Epoch of New York (3 *a*, Dana).

No. II *b*, embraces a series of heavy beds of dark blue limestones, with some dark brown and yellow shales intervening. A large proportion of the limestone is magnesian (dolomitic), and some beds hydraulic. The oxide of iron abounding in this formation, gives a dark brown color to the soils produced by its disintegration. These are among the best and most durable soils of the valley. The next and upper division (No. II *c*), is characterized lithologically, (1) by having the greater part composed of light blue and bluish-drab colored limestones, with yellow shales interstratified, especially among the lower beds; (2) by one and sometimes two beds of coarse, brown, friable sandstone between layers of light-colored limestones, and (3) by a remarkable bed of *chert* near its upper limit. This hard, flinty, durable rock has so far resisted the force of disintegrating agencies, as to be left as a covering on the faces of many of the limestone hills throughout a large extent of the Great Valley. This chert bed varies in thickness from one to ten feet within the range of a few miles; but it and the brown sandstone lower down serve as well defined land-marks for this whole formation. The brown sandstone has preserved imperfect impressions of several species of brachiopod shells, while in the chert bed are found in some localities large numbers of silicified shells of gasteropod and cephalopod mollusks. This division (*c*) by disintegration yields light clay and sandy or pebbly soils, according to the varying characters of the outcropping strata. These soils are only moderately productive—some of them very poor. Local deposits of limonite ore in this formation have been mined in past years to supply some of the iron furnaces in Augusta county.

The lithological and paleontological characters of this group of rocks, as well as its position seem to identify it with the Chazy Epoch (3 *c*, Dana).

The dotted lines on the section give an ideal representation of the foldings and inversions to which these rocks were subjected when turned up from their original bedding. There was not, of course, the regularity and symmetry in the foldings that these lines indicate, for there are along the line many evidences of local warpings, fractures, dislocations, etc., that could not appear on such a section. Several trap-dykes are found protruded through the rocks of No. II, in Augusta and Rockingham counties, but none, so far as I know, in Rockbridge. The Natural Bridge, from which this county takes its name, is in *b*—being a portion of one of its upper strata spanning a cañon or gorge, cut through its lower beds to a depth of more than 200 feet.*

No. III.—In some respects this group of rocks differs so widely here from its condition in Augusta and Rockingham counties, where Professor W. B. Rogers adopted it as typical in his earlier Reports, that I feel confident that he then regarded some of the heavy, but quite irregular beds of limestone in the Lexington basin as a part of No. II, but I am equally confident that he would, upon a more detailed examination, class them as Trenton Limestones—base of III.

The lower bed (*a*) of this group is peculiar, as far as I have yet observed, to Rockbridge and adjacent portions of Botetourt and Augusta counties. It has all the appearance of an old coral reef very much disintegrated, stratified, and subsequently solidified by the infiltration of carbonate of lime which has given the mass a crystalline texture, and converted it into a gray limestone, very compact and admirably adapted for building purposes. The bed has well defined horizons both below, where it is separated from the chert of No. II *c*, by one or two thin layers of light blue limestone; and above, where it is covered with a layer that is shaly in some places and in others very hard, and full of white veins of calcite and dolomite. The upper and lower portions of this coralline bed are quite full of shells as well as fragments of coral; the middle portion is more purely coralline, more compact, and better adapted to the architectural purposes to which it is extensively applied; and to the manufacture of lime. The most easterly outcrop in this neighborhood is on Hoffman's Run, about one mile S.E. of the town, where the total thickness is about sixty (60) feet. It seems to run out somewhere beneath the synclinal fold that forms the Poplar Hills, but appears again on Buf-

* I incline to the belief that this gorge was originally a *crevice* in the strata, and subsequently enlarged by erosion—not the result of erosion alone; the arch having escaped fracture when the crevice was produced.

falo Creek, six miles to the S.W. N.W. of Lexington the outcrop of this bed is finely displayed along some parts of the base of Brushy Hills, and especially on the North River, a mile above the town bridge, where it forms a nearly vertical cliff, exposing its entire thickness, which at this point is about 150 feet. This thickness is preserved in the synclinal between Brushy Hills and House Mountain, and also at other points where it appears below (*b*) the thicker mass of Trenton Limestone.

No. III, *b*, crops out extensively on both sides of Poplar Hills, forms the whole of the synclinal over which Lexington stands,* and is the foundation rock of the House Mountains, around the base of which it may be seen cropping out on all sides. The general position here is horizontal, or nearly so, with some local curves. Northwest of Kerr's Creek valley it disappears beneath the North Mountain.

The general structure of *b* differs very widely from all the lower limestones—the beds here, except some of the lowest, being thin layers of argillaceous limestones, with interstratified shales. Near the base of *b*, especially along its S.E. portion, underlying the Poplar Hills, we find a bed of very compact blue limestone irregularly bedded and very full of infiltrated veins; but, as we ascend, the rocks become more and more argillaceous, with the beds of shale becoming more numerous; and finally, as may be seen on House Mountain, after passing upward through a thickness of about 650 feet, the shale becomes predominant, but still contains some thin beds of limestone remarkable for the profusion of fossil shells, crinoids and coral found in them. There is no well-defined horizon here, between what is represented on the section as *b* and *c*, but the former seems in general characters to be the equivalent of the Trenton limestone, and the latter of the Cincinnati (Hudson) shales. It is about 750 feet thick.

Remark.—I have not seen any outcrop of the division, *a*, of No. III in Augusta county northeast of Staunton, nor have I seen it at all in Rockingham. If its equivalent appears in that part of the valley, it is under quite different lithological and fossil peculiarities. I might say almost as much in regard to *b;* for limestone beds form a very inconspicuous part of III, from Staunton (or rather a point S.E. of that place) to a point in Rockingham county, where it passes under IV in the Massanutton range of mountains.

"FAULT."—This seems to be the proper place for directing attention to the "Fault," the line of which passes in front (S.E.) of the House Mountain. It is easily traced for several miles

* This synclinal is really *double*—having a line of uplift running through it, but the scale of the section would not admit its insertion. There are also some local irregularities here.

both ways from one line of section. The lower and older rocks of No. II are found (in their own normal order) overlying the newer of No. III *b*, which dip beneath them. At a number of points between Kerr's Creek and Collier's Creek, two considerable streams that run out from the N. Mountain at the opposite extremities of the House Mountain ridges, this dipping of the newer under the older rocks may be seen along a line of very considerable regularity.

Our general description has now extended to the horizon between the Lower and Upper Silurian.

No. IV, the equivalent of the Medina group, is composed of very durable sandstones that are the chief mountain-making rocks along the northwest margin of the valley, and throughout a belt of twenty or twenty-five miles wide, parallel with it. It may be represented under three subdivisions. The lower one of which (*a*), is a very hard, light gray, sometimes white, sandstone, distinctly conglomerate in many places, and so durable as to present long lines of precipices where the strata crop out on the faces of the mountains. The middle member (*b*) of this group is a dark brownish purple sandstone with beds of interstratified shales of the same color. Shells in the sandstones, and fucoids in the shales, are conspicuous features of this division. A third member (*c*) is much lighter in color than *b*, but darker than *a*. Some of the harder layers have a pinkish hue, while the softer and more brittle, especially near the top, where they border on No. V, are brown and yellowish brown in color. While this group, as it appears on the two ridges of House Mountain, rests upon a nearly horizontal base, in the North Mountain its position is changed to that of a steep northwest dip.

The general pressure that acted from the Blue Ridge side of the valley towards the northwest, seems to have lifted the House Mountain ridges somewhat above what was the original level of the surrounding region, and, at the same time, to have broken off and pushed back the edges that now form the crest of North Mountain. But while the section represents the general result, it will be found on examination, that there are a number of local and limited irregularities in the form of contortions and fractures that could not be exhibited on a scale representing so much space within so short a limit. So, also, it has here, apparently, a greater degree of symmetry on the surface, than the denuding forces to which it has been subjected, have given it. But in this regard, also, the irregularities are too numerous and limited to find a place on the section.

The strata of this group all thin off as they extend farther towards the interior basin of the coal regions. They also vary much in thickness where they crop out along the margin of the

valley. What now caps House Mountain is about three hundred and sixty feet thick, while, at the highest point, it may have lost one hundred feet or more of its original height. On the Warm Springs Mountain, in Bath County, twenty miles farther towards the great Appalachian coal basin, the thickness is very perceptibly less. At Panther Gap, two or three miles west of Goshen, where the Chesapeake and Ohio Railroad passes through Mill Mountain, a very complete section of No. IV is displayed as a folded and inverted anticlinal—inverted towards the northwest so that the higher strata of V, VI and VII, seem to underlie IV.

No. V is in most places, in this part of the Appalachians, a bed of shales and brittle, shaly sandstones. In the upper part the shales predominate and have some thin bands of limestone. Valuable iron ores, some of them highly fossiliferous, abound in this formation. The development of this group is not extensive where our line of section cuts it. This seems to be the only representative we have here of the Clinton and Niagara epochs (5*b*, and 5*c*, Dana).

No. VI is not actually visible where the section passes, but its outcrops on both sides of the same valley, at points not very remote, seem to justify the hypothesis that it actually exists at this point though concealed from view by the debris of sandstone and clay from the adjacent mountain. In this part of the Appalachian range it consists almost entirely of limestones that are remarkable for the profusion of fossil coral, shells and encrinites found in them. The stone is pure enough in some of its beds to make good lime, and firm enough to make good building material for houses, railroad masonry, etc. In the prolongation of the same mountain valley, in which our section terminates, this formation is largely developed along the line of the Chesapeake and Ohio Railroad, between Goshen and Buffalo Gap. At Craigsville, nine miles northeast of Goshen, it affords an extensive quarry of beautiful encrinal marble. It is the Helderberg Limestone. (7 Dana.)

No. VII is a singular bed of brownish and greenish-gray sandstone of coarse texture, easily broken, and in many places disintegrates readily under the weather. In other localities it is more durable, forms rather low flat arches, and when cut through by streams presents precipitous exposures. It is said to have valuable deposits of iron ore at several points in Virginia. Great numbers of fossil brachiopods, especially *Spirifer arenosus* and *Rensselæria ovoides*, are found in it everywhere.

This is a remarkably well defined formation, readily distinguished by its lithological peculiarities and its fossil remains. It is cut by the Chesapeake and Ohio Railroad at several places between Buffalo Gap and Goshen. On the turnpike leading

from Millboro to the Warm Springs, about three miles from the station at which the stage coaches leave the railroad, this formation may be seen as an anticlinal arch, spanning the lower limestone of VI, in which the famous "Blowing Cave" of Bath County is situated. Here the Calfpasture River has cut through a ridge and given a natural section along the base of which the stage-road passes, and where the Oriskany and Helderberg formations are well exposed, and, together with the Blowing Cave, present points of considerable scientific interest. Here, also, the meeting of the Oriskany, the upper member of the Silurian, with the Marcellus (?) shales, at the base of the Devonian, may be distinctly observed on both sides of the ridge.

The following table exhibits a comparison of the subdivisions in this portion of the Virginia valley, with the periods and epochs in Professor Dana's Manual:

Silurian rocks of the Great Valley of Virginia with their subdivisions, compared with equivalent epochs of Dana's Manual, p. 142.

Ages	Periods.		Epochs.	Rogers' Series.		Virginia Valley Subdivisions.
Upper Silurian.	Oriskany.	8	Oriskany,	No. VII.		Spirifer Sandstone.
	L. Helderberg.	7	L. Helderberg.	No. VI.		Encrinal Limestone.
	Salina.	6	Salina.	No. V.	*c*	Calcareous Shales.
	Niagara.	5*c*	Niagara.		*b*	Ferriferous Shales.
		5*b*	Clinton.		*a*	Shaly Sandstones.
				No. IV.	*c*	Upper Sand-rock.
		5*a*	Medina.		*b*	Purple Shale and Sandstone.
					a	Conglomerate.
Lower Silurian.	Trenton.	4*c*	Hudson Riv.	No. III.	*c*	House Mt. Shales.
		4*b*	Utica.		*b*	Lexington Limestones.
		4*a*	Trenton.		*a*	Coraline Limestones.
	Canadian.	3*c*	Chazy.	No. II.	*c*	Cherty Limestones.
		3*b*	Quebec.		*b*	Dolomitic Limestones.
		3*a*	Calciferous.		*a*	Hydraulic Limestones.
	Primordial or Cambrian.	2*b*	Potsdam.	No. I.	*g*	Iron-bearing Shales.
					f	Scolithus Sandstones.
					e	Kaolin Shales.
		5*a*	Acadian.		*d*	Middle Sandstones.
					c	Middle Shales.
					b	Lower Sandstones.
					a	Lower Shales.
Azoic.	Archæan.		Archæan.	Metamorphic.	*c*	Slates and Syenite Gneiss.
					b	Bedded Syenite.
					a	Lower Slates.
				Igneous.	*E*	Eruptive Syenite.

ART. III.—*On a new form of Spectrometer, and on the distribution of the intensity of Light in the Spectrum;* by JOHN WILLIAM DRAPER, M.D., President of the Faculty of Science in the University of New York.

I HAVE invented a spectrometer which I think will open a new and interesting field to those who are engaged in spectrum analysis.

The ordinary spectroscope is occupied with the frequency of ether-vibrations or wave lengths. This, which I am about to describe, has a different function. It deals with the intensity or brilliancy of light.

It depends on the well known optical principle that a light becomes invisible when it is in presence of another light about sixty-four times more brilliant.

In some researches, published by me in 1847, on the production of light by heat or the incandescence of bodies, I used this method as a photometer, and became sensible of its value. The memoir in which those experiments are related may be found in my recently published "Scientific Memoirs," page 23.

Having also published in 1872 a memoir on the distribution of heat in the prismatic spectrum, and shown that the cause of its increasing intensity from the more to the less refrangible regions is due to the compression of the colored spaces that correspondingly takes place, owing to the action of the prism itself, but having failed to obtain satisfactory measures in the case of the diffraction spectrum, in which such compression or condensation does not occur, I was led to reflect whether better success might not be secured by attempting to measure the relative intensity or distribution of the light.

Admitting what is commonly received as true, that the yellow is the brightest of the colored spectrum spaces, and that the luminous intensity diminishes from that in both directions, above and below, I supposed that if such a spectrum was brought in presence of an extraneous light, the illuminating power of which could be varied at pleasure, that after the red and the orange on one side, and the green, blue, indigo and violet, on the other, had been extinguished, the yellow would still remain in the midst of the surrounding illumination. On making the experiment it turned out differently.

For the sake of clearness of description I will call this extraneous light, from the function it has to discharge, *the extinguishing light.*

There are many different plans by which the principle above indicated may be carried into practical effect. Several of these I have tried, and have found the following a convenient one.

Remove from the common three-tubed spectroscope its scale tube, and place against the aperture into which it was screwed a piece of glass, ground on both sides. In front of this arrange an ordinary gas light, attached to a flexible tube, so that its distance from the ground glass may be varied at pleasure. On looking through the telescope tube, the field of view will be uniformly illuminated, this being the use of the ground glass. The brilliancy of the field depends on the distance of the gas light, according to the ordinary photometric law.

1st. *Case of the prismatic or dispersion spectrum.*—If the extinguishing light be for the moment put out, and in the proper place before the slit tube the *luminous* flame of the Bunsen burner that accompanies the apparatus be arranged, on looking through the telescope a spectrum of that luminous flame will of course be seen. The slit itself should be very narrow, so that the spectrum may not be too bright.

Now let the extinguishing flame be placed before the ground glass, and a spectrum is seen in the midst of a field of light, the brilliancy of which can be varied at pleasure. If the extinguishing flame be at a suitable distance, the whole spectrum may be discerned. As that distance is shortened, first the violet, and then the other more refrangible colors in their descending order disappear, and at length in the steadily increasing effulgence the red alone remains. The yellow never stands out conspicuously as might have been expected.

This is scarcely consistent with the assertion that the yellow is the brightest of the rays. The red is plainly perceptible long after the yellow has gone. There is a greenish tint emitted by gas-light that disappears a little previously to the extinction of the red.

From these observations I think that the luminous intensity of the colored spaces has a relation to the compression or condensation that the prism is impressing upon them. It may be that, properly considered, the intrinsic intensity of the light is the same for all. In this we must always bear in mind the physiological peculiarities of the eye.

The foregoing statement is perhaps sufficiently explicit to enable any one to verify the facts. I may, however, mention some improvements in the apparatus, which experience has led me to adopt.

The intensity of the extinguishing light may be insufficient to obliterate the spectrum, even though the slit be closely narrowed. How then may the intensity of the spectrum be diminished, and that of the extinguishing light be simultaneously increased? I accomplished this by depositing on that face of the prism which acts as a reflector an *excessively* thin film of silver. This, though it was transparent to the transmitted

rays increased very greatly by its metallic reflection the extinguishing ones. I could not see any difference between the spectrum of the light that had come through this film and that before the face was silvered, but the reflected light was incomparably more brilliant. The complete obliteration of the entire spectrum presented now no difficulty.

Nothing need be said about collateral contrivances, which would suggest themselves to any one: A strip of wood a metre long, and bearing divisions served to keep the extinguishing lamp in the proper direction as regards the ground glass, and indicated its distance. I may add, however, that satisfactory observations can be made very conveniently by keeping the extinguishing flame at a constant distance, and varying its intensity by opening or closing its stop-cock. This avoids the trouble arising from moving the flame. In one instrument I caused an index attached to the head of the stop-cock to move over a graduated scale, and so ascertained how much it was opened. This, though permitting of pleasant working, had not the exactness of the method of distances.

Such are the results obtained from the prismatic dispersion of gas-light. I completed this part of the investigation by an examination of sunlight. For this purpose I resorted to the foregoing principle, introducing a beam of sunlight, reflected from a heliostat through a slit. The spectrum of this was thrown upon a paper screen, so placed that by opening or closing an adjacent window-shutter the light of the sky in greater or less quantity could fall upon the paper, and act as an extinguisher. When the shutter was fully opened the spectrum was quite obliterated, and on gradually closing it so as to diminish the extinguishing light, the red region first came into view, the other colors following in the order of their refrangibility, the extreme violet appearing last. On reversing the movement of the shutter the colors disappeared in the reverse order, the red disappearing last.

At the moment when the red was approaching extinction there always existed on its more refrangible side a gleam of grayish-green light. It was in the position of that greenish gleam which appeared as I have described when gas-light was examined. Its color recalled to my mind the faint greenish-gray light I had seen when a strip of platinum is ignited by a feeble electric current, as described in my memoir of 1847, above referred to.

Subsequently I constructed a camera having two apertures in its front. Through one of them, by a suitable arrangement of a heliostat, slit, direct-vision prism, and convex lens, a solar spectrum was formed on the ground glass. Through the second aperture, which was about an inch square, covered with a

glass ground on both faces, an extinguishing beam of sunlight passed. This ground glass served to disseminate the extinguishing light uniformly over the spectrum. I could regulate the power of this light by varying the size of the aperture through which it came by means of a slide.

It is needless to give details of the results obtained by this instrument. They were identical with those described in the foregoing paragraphs.

It might be supposed that the irrationality of dispersion of different prisms would influence the results perceptibly. Accordingly, I tried prisms of different kinds of glass and other transparent substances, but could not find that this was the case. In all, the extinction began in the violet and ended in the red.

Nor did there seem to be any difference when the effect was viewed by different eyes. To persons, irrespective of age or the condition of their sight, the extinction took place in the same manner. I had not an opportunity of examination in a case of color-blindness.

2d. *Case of the Grating or Diffraction Spectrum.*—If the cause of the increasing intensity of light in the prismatic spectrum from the more to the less refrangible region be the compression exercised by the prism on the colored spaces, increasing as the refrangibility is less, we ought not to find any such peculiarity in the diffraction spectrum. In this the colored spaces are arranged uniformly and equably in the order of their wavelengths. An extinguishing light ought to obliterate them all at the same moment.

Having modified the common spectroscope by taking away its dark box so that the slit tube and telescope tube could be set in any required angular position, I put in the place of its prism a glass grating inclined at forty-five degrees to rays coming in through the slit. The ruled side of the grating was presented to the slit. Now when the extinguishing flame was properly placed before the ground glass, the plane side of the grating reflected its light down the telescope tube. In this, as in the former case, the spectrum was seen in the midst of a field of light, the intensity of which could be varied by varying the distance of the extinguishing flame, or by varying the opening of its stop-cock. This light needs no reënforcement by increasing the reflecting power of the back face of the grating, these spectra being much more feeble than that given by a prism, and the unassisted light being quite able to extinguish them.

As the glass grating I was using gave its two series of spectra of unequal brightness, I selected the most brilliant, and in it used the spectrum of the first order. I saw, not without pleasure, that as the force of the extinguishing illumination increased, all the colored spaces yielded apparently in an equal manner, and disappeared at the same moment. Some-

times, however, there seemed to be a very slight difference in favor of the red. On diminishing the illumination all the colors came into view apparently at the same time. This spectrum gives a better opportunity than the prismatic for observations on the yellow space, which by being uncompressed, exposes a wider surface to view. This yellow space showed no superiority in resisting extinction over the other colors.

But as gas-light, compared with sunlight, is deficient in the more refrangible rays, I repeated the examination of the latter, as I had previously done for the prismatic spectrum, modifying the apparatus so as to use a grating in the place of the prism. The observations in this case of sun-light were quite as satisfactory as those in which gas-light had been used.

General conclusions. — 1st. In the prismatic spectrum the luminous intensity increases from the more to the less refrangible spaces, its maximum being not in the yellow but in the red. This is due to the action of the prism, which narrows, and as it were, condenses the colored spaces more and more as we pass toward the red, increasing the intensity of the light as it does that of the heat.

2d. In the grating, or diffraction spectrum, the luminous intensity is equal in all the visible regions, all the colors being simultaneously obliterated by an extinguishing light.

It must, however, be borne in mind that these conclusions should be taken in connection with the physiological action of the eye. Owing in part to the imperfect transparency of its media, and partly to the inability of its nervous mechanism to transmit waves of certain frequency to the brain, the spectrum does not begin and end sharply, as to a perfect eye a perfect spectrum ought to do.

There are, hence, two causes which must not be overlooked in these observations. 1st. The physiological peculiarity of the eye, which gives to each end of the spectrum the aspect of gradually fading away. 2d. In the case of solar-light the absorptive action of the atmosphere, which is chiefly exerted on the more refrangible rays.

I think, bearing in mind the correlation of light and heat, both being corresponding manifestations of the same vibratory movement in the ether, that these results substantiate those I published in 1872, on the distribution of heat in the spectrum; and that as the different colored spaces are equally luminous, so they are equally warm.

I have made some attempts to compare with each other the luminous intensity of the bright lines in various spectra, especially those emitted by a strontium flame, but not being able to continue these researches at present, I have postponed them to a more favorable opportunity.

University of New York, May 5th, 1879.

ART. IV.—*On the Extinct Volcanoes about Lake Mono, and their relation to the Glacial Drift;* by JOSEPH LECONTE.

[Read before the National Academy of Sciences, April 16, 1879.]

IN 1870, and again in 1872, in company with a party of students and graduates of the University of California, I visited the Mono region. But on both occasions my attention being specially directed to the study of the ancient glaciers, I examined the volcanoes only somewhat cursorily. In 1875 with a similar party I again visited the same region, and this time remained longer and examined more carefully, though on account of an unfortunate accident, not so long or so carefully as I desired. I have put off from year to year the publication of the results of my observations in the hope of again visiting the region and settling some doubtful points which still remained. There seems now, however, little likelihood that I shall ever be able to carry out my intention, for other questions of still greater interest have in the meantime engaged my attention. I will therefore no longer withhold my imperfect observations, hoping that they will be corrected and extended by others.

General description of the region.—Eastern slope of the Sierra.—As already explained in previous papers,* the general form of the Sierra is that of a great wave ready to break on its eastern side. It rises from the San Joaquin plains by a gentle slope which extends 50 to 60 miles, reaches a crest 13,000 feet high, then plunges downward by a slope so steep that it reaches the plains of Mono 6000 ft. above sea level, in five or six miles. In glacial times, long, complicated glaciers with many tributaries occupied the western slope, while on the east, comparatively short simple glaciers came down in parallel streams and ran far out on the level plain and into the swollen waters of Lake Mono, which, then nearly 700 feet above its present level and far beyond its present limits, washed against the base of the Sierra itself. There can be no doubt that these glaciers formed icebergs which floated on the surface of the great inland sea and dropped débris over its bottom.

The Plains.—Surrounding Lake Mono and sloping imperceptibly to its surface, is a nearly level desert plain, covered with volcanic sand interspersed with fragments of pumice and obsidian, and overgrown with sage-brush (*Artemisia tridentata*). It is undoubtedly an old lake bottom, subsequently covered with volcanic ashes. The dreary prospect of this desert is relieved by the magnificent irregular Sierra wall trenched with deep cañons; by long parallel moraine ridges stretching like arms from the mouth of each cañon, five or six miles out on

* This Journal, III, v, 325, 1873; x, 126, 1875; xvi, 95, 1878.

the level plain, and bounding the pathways of ancient glaciers; by a fine cluster of recently extinct volcanic cones fifteen to twenty in number and very perfect in shape, and finally by the bright waves of the lake studded with picturesque islands.

Moraines.—Some of the parallel moraines which form so conspicuous a feature of the scene, especially those of Bloody cañon, I have already described.* From the top of any of the higher volcanic cones, many others may be seen stretching out upon the plain. These moraine ridges average 300 to 400 feet in height and five to six miles in length, but some of them, especially those at the head of Rush Creek, are much higher. The view of glacial moraines here presented is incomparably the finest I have ever seen.

Lake.—Lake Mono is a fine sheet 14 by 10 miles in extent. There being no outlet the waters are of course saline. It is essentially a strong solution of sodium carbonate, with smaller proportions of lime carbonate, common salt and borax. To the taste it is simply a concentrated solution of carbonate of soda. While camping on its margin we found its powerful detergent property very useful in clothes-washing. The mineral contents are probably partly the concentrated leachings from the volcanic rocks which cover the whole plains—the alkaline silicates of these rocks being changed into alkaline carbonates by carbonic acid of the air—and partly contributed by springs which issue in many places from the bottom and around the margins of the Lake, and were probably more numerous and active in former times. In any case, the lake waters are now but the concentrated residues of a much larger body of water, as plainly shown by the terraces to be presently described. During the process of concentration the less soluble lime carbonate has been deposited in strange irregular masses of calcareous tufa. These curious fungoid and coralloid masses, some of them six to ten feet in height, stand up thickly on the level shores and in the shallow marginal waters of the lake. At a distance they look like the half-submerged stumps of a forest of gigantic trees. This carbonate of lime deposit is evidently identical with the thinolite deposit described by King† as occurring in such immense quantities about the residual lakes of the Nevada basin farther north, and which as he shows is a pseudomorph of carbonate of lime after Gay-Lussite. The conditions under which the deposit took place about Mono are probably, however, slightly different from those in Nevada, and I believe throw much light on the general question of thinolite deposits. It deserves careful study and I hope to take it up in a subsequent paper. Farther east, near Columbus, Nevada, in the region of the dried-up lakes left at the extreme southern exten-

* This Journal, III, v, 325. † Geol. Exploration 40th Parallel, i, 508, and seq.

sion of King's ancient lake *Lahontan*, occur remarkable deposits of ulexite (soda-lime borate) which also deserve separate study.

Terraces.—I have already mentioned the terraces about Lake Mono. Several of these are very distinct and traceable all around the lake. But they are seen in greatest number and most distinctly on the west side, where the lake approaches the Sierra and the hills rise abruptly from the lake-level. Five or six may here be counted, rising one above the other like level benches, the highest being, according to Whitney, 680 ft. high. These terraces are undoubtedly the marks of old lake levels, and show not only a former greater depth but also a much greater extent of the lake waters. The highest level traced about the lake would reach the moraines at the foot of the Sierra, extend beyond the plains on every side, and enclose an area many times greater than the present lake-area. There can be no doubt therefore that the great glaciers of that time ran into the lake and formed icebergs.

Islands.—Near the center of the lake there is a group of volcanic islands in direct line with the groups of volcanic cones on the plains to the south and doubtless a continuation of the same line of volcanic activity. The largest of these islands is about 2½ miles long, a mile wide and about 300 feet high. It is composed mainly of extremely fine, whitish material, beautifully and very finely laminated, the differently colored laminæ being very distinct and scarcely thicker than cardboard. This material is spoken of by Whitney* as volcanic ashes. Under the microscope it proves to be composed wholly of *diatom shells* with only an occasional grain of sharp sand. There is no doubt therefore that it was deposited very slowly in calm waters, in the middle of the lake and beyond the reach of detritus. The stratification is mostly horizontal; only in two or three places where the deeper strata are exposed on the cliffs by the action of waves, I observed a slight dip, and in one place a gentle but distinct *anticline*, showing a quiet upheaval of the whole mass, as I think, by volcanic forces. In the highest parts of the island, the soft, horizontally-laminated earth is sculptured by erosion into sharp pinnacles and turrets like bad-land structure on a small scale. On the eastern portion of the island a considerable area of black basaltic rock is exposed, but this is no where more than 50 feet high. Where the diatomaceous earth comes in contact with the basalt, the former always overlies the latter in undisturbed horizontal layers. I conclude therefore that the basalt preceded the formation of the diatomaceous mud, was once entirely covered by the latter, and was subsequently exposed by erosion.

* Geol. Survey of California, i, 453.

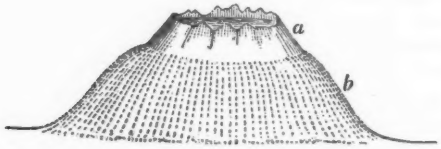
Steam and boiling water issue in many places in this rocky portion of the island and in the shallow water in the vicinity. I observed also in the earthy portion crater-like depressions, containing a little saline water, which were probably produced by similar fumarole action now extinct. According to Whitney (p. 453) two distinct true craters occur in the basalt on the northeast portion of the island; but these I did not see.

The other and much smaller islands I did not have time to visit, but according to Whitney, they are wholly basaltic, and the largest of them is 300 feet high, and is a well-defined volcanic cone.

The general conclusion, at which I arrived from my examination of the largest island, was that the basaltic portion was first formed at the bottom of the lake, or else subsequently submerged; then the diatomaceous mud was deposited, covering it up completely; then the fine mud-bottom was raised into an anticline and exposed as an island by the fall of the lake level, and finally erosion sculptured the whole, and in part exposed the underlying basalt.

Volcanoes on the Plains.—We have already alluded to a conspicuous group of volcanic cones situated on the level plain south of the lake. These are twenty or thirty in number, extending in a line from near the margin of the lake to a distance of ten to fifteen miles, and vary in height from 200 to 2,700 feet above the plain. Partly from the recency of their

1.



extinction, and partly from the small rainfall of the region, they are, some of them, as perfect in form as if they were still in action. A good general view of these is given by Whitney in his account of this region. The typical form of the more perfect is shown in fig. 1, which, though intended only as a diagram, is yet a tolerably correct outline of the highest and most perfect. The upper part *a* is a light-colored pumiceous lava, and the lower part *b* is covered with sand of the same.

In many cases I observed a very perfect cone-and-rampart structure, such as is known to be produced by great eruptions, followed by smaller ones; or perhaps in some cases by an engulfment of the crater into the base of the cone. The most perfect example of this kind is found in a small and easily accessible cone, not far from the lake. Fig. 2 is an ideal

section and half perspective view of this cone. It consists of a low sand cone about 200 feet high, with a perfect circular crater one and a half to two miles in circumference, from the center of which rises a trachytic cone and crater of much smaller dimensions, to about the same height. From the

2.

shattered condition of the inner cone, Mr. Muir suggested to me the possibility of the engulfment of the upper rocky portion into the lower sandy portion of a once much higher cone. But, in many other cases observed, this explanation is evidently untenable; for in some cases we found several small cones surrounded by one rampart. Such could only be formed by successive eruptions.

The material erupted by these volcanoes is in some cases basalt, but by far the largest amount consists of feldspathic slags, pumice and pumiceous sands and ashes. The whole plains of Mono are covered to a depth of many feet with a nearly white volcanic sand, mingled with fragments of pumice and obsidian.

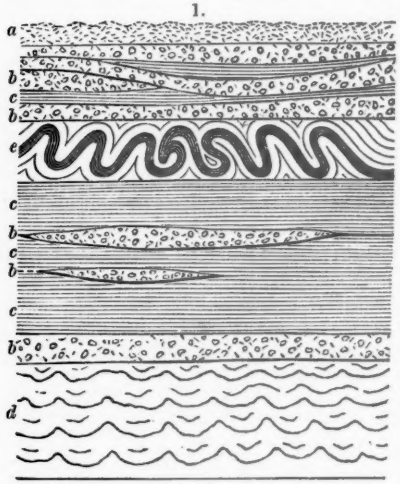
Age of the Mono Volcanoes.—There is abundant evidence that these volcanoes have been active, and therefore that they assumed their present forms since the epoch of great separate glaciers in this region (Champlain). Whether they also existed and erupted previously is perhaps doubtful though probable. The evidences of the extreme recency of the eruptions, which determined their present forms, are as follows:

1. We have already shown the splendid scale on which glaciers were once developed in this region. We have already given reasons for thinking that they ran down the Sierra, out on the plains and into the lake, and produced icebergs there. It is impossible that the volcanic cones, if they then existed, could have escaped the powerful action of ice, and the equally powerful action of other meteoric agencies, so characteristic of that epoch, which must have entirely destroyed their form. The remarkable perfection of their conical forms and of their craters is therefore strongly presumptive if not demonstrative, of the fact of their eruption since the disappearance of the glaciers.

2. All the streams, which run from the Sierra into Lake Mono, cut into the level plains 100 to 150 feet deep. Fine sections of the materials of the plains are thus exposed. Fig. 3 is the upper portion of such a section about eighty feet perpen-

dicular. The lower portion of the cliff, being covered up by talus, is not represented. It is seen that nearly the whole is an ordinary modified drift, composed of irregularly stratified sands and clays, *cc*, intermingled with layers of pebbles and gravel, *bb*. But there are other parts that deserve more special notice. The stratum *e* is a fine light-colored clay, through which runs a deep chocolate-brown lamina scrolled in the most complex and beautiful pattern; the stratum *d* is also strongly crumpled. This crumpling and scrolling of the strata could have been produced only by a glacier advancing on a bed of stratified clay, or else by the pushing of icebergs on a stratified lake bottom. I suppose the whole formation except *a* to have been produced by an alternately advancing and retreating glacier; now retreating and dropping material, to be carried and deposited by the river which flowed from its snout, now advancing and crumpling the finer material of the lake bottom. It may be difficult to explain the details of the process, but I think it will not be doubted that the whole is a distinctly marked drift-deposit. Many other similar sections were observed; some of which were 150 feet thick.

1.



a = unstratified volcanic sand.
bb = pebble and gravel.
cc = fine sand and clay stratified.
d = strata crumpled by moving strata.
e = strata scrolled by same agency.

Now covering everywhere this undoubted glacial material is found a layer of loose, unstratified volcanic sand and pumice, *a*, which has evidently never been touched by the action of water. It is a pure eolian drift. In the section it is about three feet thick, but it is really much thicker, as it thins off on the margin of the perpendicular cliff by falling, and thus contributes to the talus at its base. It is evident that the whole material of the section was deposited during glacial times, except *a*, which was drifted over the bared lake bottom since that time. But judging from the immense quantity of this loose material, covering as it does the whole plain many feet deep, it seems impossible that it is the mere result of disintegration of the vol-

canic cones in recent times. I suppose, therefore, that it is the result of sand and ash eruptions since the recession of the lake waters.

3. We have already described the material of the largest island as being composed wholly, except a portion of the eastern part, of a fine infusorial earth, horizontally stratified with laminæ of slightly different colors, so thin as to give specimens an almost agate-like beauty. This material was evidently deposited in the middle and deepest part of the lake, beyond the reach of coarser sediments, at a time when the place of the island was still a lake bottom. Now, that this occurred during or after the epoch of great glaciers, is demonstrated by the fact that scattered sparsely through this fine laminated material, and lying on its surface, having been washed out by erosion, I found many bowlders, both worn and angular, of Sierra granite and slate, and also of obsidian. These could have been brought there only by the agency of floating ice, either as icebergs or as shore ice. If by icebergs, of course during the epoch of great glaciers; if by shore ice, either during that time or still later, for manifestly the bowlders were brought down to the shore from the Sierra during that time. It is evident, therefore, that the stratified mud was formed and the bowlders were dropped during the period of great glaciers or later. But still later the island itself was upheaved by volcanic action, as shown by the anticlinal position of the strata at the base, and by the solfataric action still going on. The formation of this island I suppose to have been coincident with the last eruptions of the volcanoes on the plains.

4. Within the craters of several of the volcanic cones on the plains, I found pebbles and angular fragments of granite of a peculiar reddish color from the presence of a rose-colored feldspar. Whitney observed the same, and accounts for them in the following manner: They could not, he thinks, have been brought by glaciers or by water, for this is inconsistent with the perfect shape of the cones. He rightly concludes therefore that *they must have been* ejected from the volcanoes. But if so, he says, "*they must have been torn off from the underlying granite, through which the eruptive matter has forced its way, as is seen everywhere in the Sierra.*"* On the contrary, I account for them in a wholly different way. The fragments which I saw were some of them angular—true; but *most of them were well-worn pebbles.* There is not the slightest doubt that *these were pebbles of the drift-layer which everywhere underlies the loose sand of the plains.* The eruptive forces broke through this drift-layer, and the ejected pebbles fell back into the crater. They demonstrate that the cones and craters, where they are found, not only

* Geol. Survey of Cal. vol. i, p. 455.

erupted, but *were wholly formed*, after the epoch of the pebble drift.

I think, therefore, there can be no doubt that all of these volcanoes erupted, and many of them were wholly formed after the epoch of great glaciers (Champlain). Whether any of them preceded that epoch is doubtful. I have never seen any undoubted evidence that they did. If the bowlders found on the island were carried there by icebergs, then volcanic action preceded the epoch of icebergs, for many of the fragments are volcanic; but they may have been carried by shore ice at a later time. Again, I believe the rocky part of the island is older than the sedimentary part, for the latter seems to have been deposited on the former. If the sedimentation was Champlain, then the rocky part was probably pre-glacial; but the sedimentation may have been later.

Sequence of Events.—Assuming that the island strata belong to the epoch of great glaciers, then the order of events was something like this:

1. Volcanic eruptions on the plains producing obsidian, fragments of which were afterwards carried by ice and dropped in mid-lake. At the same time also, the basaltic part of the islands was formed.

2. Then followed the period of great glaciers and flooded lakes, or Champlain epoch. The lake was nearly 700 feet higher than now. Its waters covered the whole plains and washed against the Sierra; and glaciers from this range ran far into the lake and formed icebergs, which floated over its surface and dropped rock-fragments over its fine mud bottom.

3. Volcanic forces, acting quietly like the solfataras and fumaroles still existing, heaved up the stratified mud-bottom of the mid-lake into a gentle mound with quaquaversal dip of the strata, but not rising to the surface. Coincident with this were the eruptions of the plains volcanoes.

4. The lake then dried away gradually to its present level, leaving the terraces as its old flood-marks, and exposing the rounded mud-island; and erosive agents then sculptured this into its present turreted form and cut away its margin to its present limits, and exposed the mud-covered older basaltic part.

Lake rising again.—The existence of salt and alkaline lakes shows an extreme dryness of climate. But the climate of the desert region has not always been dry. During the Champlain epoch the interior plains were covered with immense sheets of water, of which the present saline lakes are the isolated residues. Gilbert has shown that at that time Great Salt Lake contained 400 times as much water as now, and that it drained northward through the Snake and Columbia Rivers into the

Pacific ocean. King has shown that the Nevada basin was at the same time occupied by a vast irregular sheet of nearly equal extent, stretching southward as far as Columbus, Nevada. Pyramid, Winnemucca, Carson, Humboldt, and Walker Lakes, are the concentrated residues of this great lake. Lake Mono also, we have seen, at the same time, was a great sheet of water, whether connected with the other or not is not known. There has been therefore an increasing dryness of climate in that region since the Champlain. Is it still progressing, or has it reached its maximum? This is an important question for the Pacific States.

From my observations on Lake Mono, I have no doubt that its level, at the time of my visit, was rising and had been rising for ten or fifteen years. The evidence is as follows: Around the margin of the lake I found everywhere old fences of sheep *corrals* and old trails submerged many feet deep. While visiting the island I found the vegetation of the island, sage brush (*Artemisia tridentata*), and grease wood (*Sarcobatus vermiculatus*), submerged in five feet of water, and of course killed. Residents about the lake state that the waters have risen ten to twelve feet in ten or fifteen years. I might be disposed to doubt these observations if the same phenomena had not been observed in other lakes in the same dry region. Salt Lake is known to have risen ten to fourteen feet in twenty five years and submerged large tracts on its flat margins, and the water by analysis is far less salt than formerly. Pyramid Lake, according to King, has risen nine feet, and Winnemucca Lake twenty-two feet in only four years—1867–1871. The same is said to be true of Walker Lake and of Owen Lake.

The cause of this is evidently increase of rain-fall and snow-fall, chiefly the latter. In this connection it may be well to mention an additional evidence of increasing snow-fall in the Sierra. I have in a previous paper* drawn attention to a moving snow-field, or rather an imperfect *glacier*, occupying the great cirque at the top of Mount Lyell, the feeble remnant of the great Tuolumne glacier of glacial times. At the foot of this *glacieret* there is as perfect a terminal moraine as ever was seen. It is a crescentic pile of rock fragments twenty feet high, fifty feet wide at base, and about a mile long. The fragments were brought down by the moving ice from the vertical cliffs of the cirque. Many similar fragments are seen lying on the glacier on their way to the moraine, and in various stages of advance. Now not only does this moraine show no signs of being left by a *retreating* glacier, but on the contrary I think it shows signs that the ice is *advancing*. For the snout of the glacieret is not only pressed hard against the moraine but the

* This Journal, III, v, 325.

outer slope of the moraine, when I saw it, in 1872, was just at the *limit of stability*—the least disturbance caused the fragments to roll down. It would seem therefore that the moraine is being pushed slowly forward. Whether the same is true still I know not.*

King, in his recent volume on Systematic Geology, already referred to, has drawn attention to still other evidence of snow advance in the high Sierra. According to him, above the timber belt, there is a comparatively bare region of one thousand feet vertical, on which for ages there has been too much winter snow to allow the growth of timber. In the timber region bordering the bare region there are many trees which have two hundred and fifty annual rings. These trees have therefore been growing securely for two hundred and fifty years. But since 1860 the snow has so advanced upon the timber region that these great trees are being destroyed by avalanches. It would seem therefore that not only has there been recent advance, but that it is the first advance for two hundred and fifty years.

The rise of the lakes in the desert region is therefore undoubtedly the result of a climatic cycle. But whether the cycle be a long or a short one; whether it be a geological cycle of increasing snow-fall—a turn of the cycle of dryness which, commencing after the Champlain epoch, culminated in the present arid condition of the desert region—or whether it be only a climatic fluctuation of short duration, and of which therefore geology takes no account, such for instance as may be supposed to be connected with the sun-spot cycle, it is impossible with certainty to determine without observations extending through a much longer period of time. I have hitherto been disposed to think the latter more probable, but King's observations on destruction of trees by avalanches, would seem to point to the probability of a long cycle.

* King, in his recent volume on Systematic Geology of the 40th parallel, p. 477, says that all Mr. Muir's living glaciers of the Sierra are only moving snow-fields well known to the California surveyors. He then quotes Agassiz defining the distinction between such moving névés or snow-fields and true glaciers. This distinction according to Agassiz consists in the ability to bear rock fragments on its bosom and thus to form a moraine. Now, it is but justice to Mr. Muir to say that the ice in the Lyell-Cirque does bear large rock fragments on its surface and accumulates them at its lower limit as a perfect terminal moraine. Recognizing, however, the fact that this ice mass does not emerge from its native cirque, I have, in my paper on "Ancient Glaciers of the Sierra" (this Journal v, 325), called it a *Glacieret*.

Berkeley, California, March 1, 1879.

ART. V.—*On the Mineral Locality in Fairfield County, Connecticut;* by GEORGE J. BRUSH and EDWARD S. DANA. Third paper.

IN the present paper we purpose giving an account of the results of our exploration of the Branchville locality during the past year, so far as they relate to the manganesian phosphates. In our preceding papers,* we have confined ourselves almost exclusively to the original body of phosphates exploited by Mr. Fillow; we having mentioned in addition only the occurrence of a single small deposit of lithiophilite. When we first opened the locality, our hope was to rediscover the body of minerals from which the specimens preserved by Mr. Fillow had been obtained. Our success in this was quite indifferent; we did, indeed, find the spot aimed at, and took from it a small quantity of the minerals in which we were interested, but it was soon clear that this deposit was exhausted, and we must look farther for other and independent ones. Having but little to guide us in our explorations, we extended them quite widely in the seemingly most probable directions and expended, in time and money, more than our final success would, perhaps, have warranted. We discovered, however, many interesting points in regard to the minerals occurring in the vein as a whole, which we intend to describe in another paper.

Lithiophilite.—As regards the phosphates, the mineral lithiophilite has been proved to exist in considerable quantities. It occurs usually not in large deposits, but in single, isolated masses, from the size of a cherry to others several inches across. The method of occurrence is quite uniform. The masses are irregular in shape, sometimes rounded, sometimes angular, and interpenetrating the associated minerals in the most intimate manner. These associated minerals are more particularly feldspar, usually albite, and spodumene. The latter mineral is very generally altered, and the various products of its alteration, of which cymatolite is the most common, we shall describe in another place. The lithiophilite, however, though often coated black externally, is otherwise quite free from alteration; the only exception to this was in the case of that first discovered, which was situated near the surface of the ledge and was much oxidized. It will be remembered that, in what we have alluded to as the original deposits of phosphates, the lithiophilite occurred very sparingly and only as an occasional nucleus of masses of the abundant black mineral, the product of its alteration. This is described in our preceding paper, and analyses of these oxidation products are there given.

* This Journal, July and August, 1878, May, 1879.

The lithiophilite of which we are now speaking has, in almost all cases, the salmon color of that first described. In one specimen the amount of iron was determined by Mr. Penfield and found to be but 3·56 per cent. The lithiophilite sometimes contains imbedded rhodochrosite. Other constantly associated minerals are: apatite, garnet, uraninite in brilliant black octahedrons, uranium phosphates, and a silicate containing uranium, near cyrtolite, all of which will be described later.

The lithiophilite was the only mineral of the manganesian phosphate group found in these small isolated deposits. A larger mass finally reached, however, gave us another variety of this mineral, and also several of the other species. This mass was of so peculiar a nature as to deserve a somewhat minute description. It afforded first, for the most part, only lithiophilite, but of a different color from that before obtained, and of slightly different composition as shown by the analysis given on p. 47. Closely associated with the lithiophilite was a considerable amount of a granular, often also cellular, manganesian carbonate, rhodochrosite. This was quite impure, often containing interpenetrated crystals of white apatite, and also quartz. With the lithiophilite and rhodochrosite, are small quantities of eosphorite and triploidite and traces of dickinsonite; we were interested in finding hand specimens, showing all these phosphates together, entirely free from alteration, and in such a juxtaposition as to seem to prove a contemporaneous origin. Crystallized out in cavities in the rhodochrosite and again in thin seams or strings through it was a reddish-brown mineral which proved to be chabazite.

Immediately connected with the minerals described, was a large mass of a green chloritic mineral, of which we took out some hundred pounds; this we describe minutely on a subsequent page. Its especial interest lay in the intimate manner in which it was associated with the minerals just mentioned. This is particularly true of the eosphorite, which was scattered irregularly through it in nodules of great variety in shape and size. These nodules have often a banded coating of a firm whitish substance, which may have been derived from the alteration of the original mineral, and which entirely conceals the eosphorite within.

Having given this general description of the method of occurrence of these minerals, we will now proceed to describe some of them more minutely.

Lithiophilite.

We have already stated, that almost all of the lithiophilite discovered was similar in its salmon, and salmon-pink color, and, as far as tested, in composition, to that described in our

first paper; in other words, it contains from three to four per cent of iron protoxide. The lithiophilite, associated with the green chloritic mineral, has a light clove-brown color. It has a brilliant luster and is clear and transparent. The specific gravity is 3·482. An analysis* by Mr. S. L. Penfield, afforded the following results:—

	I.	II.	Mean.	Atomic relation.		
P_2O_5	45·22	45·22	45·22	P	----	·636
FeO	13·10	12·92	13·01	Fe	·180	= ·631
MnO	31·93	32·12	32·02	Mn	·451	
Li_2O	9·26	----	9·26	Li	·618	= ·628
Na_2O	0·28	0·30	0·29	Na	·010	
H_2O	0·17	----	0·17			
Gangue	0·31	0·28	0·29			
			100·26			

The ratio, $P : \overset{II}{R} : \overset{I}{R} = ·636 : ·631 : ·628$, corresponds very closely with the formula previously accepted,

$$\overset{I\ II}{RR}PO_4 \text{ or } \overset{I}{R_3}PO_4 + \overset{II}{R_3}P_2O_8.$$

It will be observed that the amount of iron in this variety of the mineral is considerably greater than in that first described and alluded to above. This result is not surprising, and indeed was anticipated from the color of the specimen. Mr. Penfield, in the article referred to, has brought together the analyses of several varieties of triphylite and the two of lithiophilite, and thus shows the gradations between the two species. The one extreme is the Bodenmais triphylite with 36·21 p. c. FeO, and 8·96 p. c. MnO, and the other the original lithiophilite, with 4·02 p. c. FeO, and 40·86 p. c. MnO. The relation between these two minerals, is closely analogous to that existing between the iron and manganese carbonates, siderite ($FeCO_3$), and rhodochrosite ($MnCO_3$). There is the same similarity in physical characters, the most pronounced difference being here as there in the color, so that the necessity of giving the two minerals of the triphylite group distinct names cannot be questioned.

Eosphorite.

The eosphorite we have spoken of as forming nodules imbedded in the massive green chloritic mineral. It occurs only massive, but shows the characteristic cleavage distinctly and is clear and lustrous. The color is a beautiful pink, sometimes quite deep. The specific gravity is 3·11. An analysis by Mr. Horace L. Wells gave the following results:—

* This analysis has already been published by Mr. Penfield in an article on the composition of triphylite; this Journal, March, 1879.

			Ratio.	
P_2O_5	31·39	P_2O_5	·221	1·06
Al_2O_3	21·34	Al_2O_3	·208	1·
FeO	6·62	FeO	·323	
MnO	22·92	MnO	·092	2·12
CaO	1·48	CaO	·026	
H_2O	15·28	H_2O	·849	4·04
Insol.	1·46			
	100·49			

The ratio of $P_2O_5 : Al_2O_3 : RO : H_2O$ is very nearly 1 : 1 : 2 : 4 or that given in our former paper, and upon which the formula was based, viz :—

$$R_2AlP_3O_{10}, 4H_2O \text{ or } AlP_3O_8 + 2H_2(Mn,Fe)O_2 + 2aq.$$

The Green Mineral.

The larger part of this deposit consisted, as already stated, of a soft green compact mineral, varying in tint from light grayish and yellowish-green to dark blackish-green. Luster dull to greasy. Hardness = 2·5. Specific gravity of the purest portions = 2·85 to 2·89. This material was exceedingly impure, containing, imbedded in it, the feldspar and mica of the vein, also quartz, apatite, chabazite, as well as the phosphates, most conspicuously among these, the eosphorite. It was possible, however, to obtain small hand specimens showing the green mineral in a state of comparative purity. A series of ten thin sections was prepared from specimens which appeared most homogeneous, and these were carefully examined under the microscope. It was found from them, that the substance was, for the most part, fine granular and crypto-crystalline, but that numerous quartz grains and apatite needles were scattered through it. The crypto-crystalline ground-mass could not be resolved under the microscope and had every appearance of homogeneity, but it would be unsafe, considering the nature of the substance, to assert this positively. In any case the presence of distinct, though microscopic impurities, makes it quite hopeless to think of obtaining a definite chemical composition.

A specimen as pure as we were able to obtain, has been analyzed by Mr. Horace L. Wells with the following result:—

	I.	II.	Mean.	Ratios.
SiO_2	20·71	20·73	20·72	·345
Al_2O_3	14·71	14·64	14·67	·158
Fe_2O_3	2·67	2·67	2·67	·016
FeO	19·48	19·65	19·56	·272
MnO	2·21	2·23	2·22	·031
MgO	5·22	5·16	5·19	·130
Na_2O	0·51	----	·51	·008
K_2O	0·09	----	·09	·001
Li_2O	*tr.*	----	*tr.*	
CaO	12·40	12·27	12·34	·220
P_2O_5	8·81	8·87	8·84	·622
Insol.	3·84	3·94	3·89	
H_2O	8·83	8·84	8·84	·491
			99·54	

It is evident from the above, independent of the microscopic examination, that the substance analyzed is not a simple mineral. If we assume the 8·84 per cent of phosphoric acid to be combined with sufficient lime to form the mineral apatite, and deduct this amount and also the insoluble matter, we have a remainder of 75·19 per cent, which when calculated to the original amount gives the following composition:—

SiO_2	27·43	MgO	6·87
Al_2O_3	19·42	CaO	0·95
Fe_2O_3	3·54	Na_2O	0·68
FeO	25·89	K_2O	0·12
MnO	2·94	H_2O	11·70
			99·54

It is scarcely admissible to attempt a formula for a substance which is so evidently a mixture, but we believe the results indicate that the green mineral is unquestionably a variety of chlorite. The analysis, excluding apatite and the insoluble residue, brings the composition very near that of delessite and prochlorite. Its physical characters, also, confirm its claim to be referred to the chlorite group.

The mineral gives water in the closed tube, and B. B. fuses to a black magnetic mass; with the fluxes it reacts for silica, iron and manganese. Soluble in hydrochloric acid with separation of silica, and an insoluble residue which was separated from the silica by solution of the latter in boiling carbonate of soda. The insoluble residue proved to be a silicate of alumina, possibly cymatolite which occurs at the locality in great abundance.

Chabazite.

This species occurs of a dark yellowish to reddish brown color, in irregular masses disseminated through quartz, and sometimes imbedded directly in the green chloritic mineral, and also in the massive manganesian carbonate occurring with the lithiophilite. A few small crystals, $\frac{1}{4}$ to $\frac{1}{2}$ inch over, were found in cavities. This singular mode of occurrence, in irregular spots and strings imbedded in other species, was so unlike the ordinary association of chabazite, that we could scarcely credit its being this species, although the pyrognostic characters, rhombohedral form ($R \wedge R = 96° 45'$), density, hardness and other physical characters plainly indicated its specific relations. The analysis given below, however, renders its identification with chabazite complete; this analysis was made by Mr. Penfield on the purest material which could be obtained. It was found impossible to separate it entirely from the quartz.

The chabazite has a vitreous to sub-resinous luster. The hardness is 4·5 and the specific gravity is 2·16.

An analysis of a carefully selected specimen by S. L. Penfield gave

Silica	49·22
Alumina	17·58
Iron sesquioxide	1·99
Manganese protoxide	0·56
Lime	6·73
Potash	2·83
Soda	1·44
Water	17·83
Quartz	2·78
	100·96

Rhodochrosite.

It will be seen from what has been said in this and in our first paper, that rhodochrosite is a very common mineral in its association with the phosphates. In the first deposit it occurred sometimes in specimens of large size with the characteristic color and cleavage ($R \wedge R = 106° 49'$), and again in granular aggregates interpenetrated with quartz, and often taking a greenish color from the dickinsonite. It also appears altered to a black, highly lustrous mineral, containing only the oxides of iron and manganese.

In the deposits which form the special subject of this paper, the rhodochrosite occurs first of a pink color implanted in the lithiophilite and hardly to be distinguished from it except by its cleavage; and again in large masses of a white or faintly pink color, granular texture, and made very impure from the admixture of quartz and apatite. This variety of the mineral occurs with the clove-brown lithiophilite and the green chloritic mineral, and contains in cavities crystals of quartz, apatite and chabazite. We add here an analysis by Mr. S. L. Penfield, of the first discovered rhodochrosite; specific gravity = 3·76.

	I.	II.	Mean.		Ratio.	
CO_2	37.78	37·80	37·80		·859	1
FeO	16·74	16·78	16·76	·233		
MnO	44·68	44·50	44·59	·628	·867	1
CaO	0·33	0·33	0·33	·006		
MgO	*tr.*	*tr.*	*tr.*			
Insoluble	0·35	0·29	0·32			
	99·88	99·70	99·80			

The variation in color of the mineral implies that the composition varies widely, which would doubtless be shown, could analyses of different varieties be made. The interest connected with the subject is, however, small, although the large amount of iron present is worthy of note.

ART. VI.—*Note on the Progress of Experiments for comparing a Wave-length with a Meter*; by C. S. PEIRCE. Communicated by the Superintendent of the U. S. Coast and Geodetic Survey.

To C. P. PATTERSON, Superintendent U. S. Coast and Geodetic Survey:—

DEAR SIR—The following is the present state of the spectrum meter business. The deviation of a spectral line (Van der Willigen's No. 16) has had three complete measures using a certain gitter of 340½ lines to the millimeter. The double deviation (the angle measured) was found to be

1877.	June 23,	89° 54′ 19″·5
	June 29 and July 2,	19·25
	Sep. 4 and Aug. 27,	19·65
	Mean,	89° 54′ 19″·5

An error of 0·4″ in this would occasion an error of one micron in the meter. These measures were previously communicated to you, but owing to an erroneous value of the coefficient of expansion of glass having been used (the value for iron having been inadvertently substituted) they did not seem to agree as well as they do. There were two other complete measures, but in regard to one of them there is a doubt about the thermometer used, and in regard to the other there is a doubt about the part of the line set on. This line seems on the whole to be a bad one for the purpose. Another line near it was therefore selected and another much finer gitter. The deviations obtained were on the different days:

1879.	May 8,	90° 03′ 51″·7	May 15,	90° 03′ 50·35
	May 9,	51·75	May 21,	51·75
	May 10,	52·0	May 22,	51·2
	Mean,	90° 03′ 51″·45		

Notwithstanding the bad result of May 15, which is unaccountable, these measures are evidently good enough. One of these gitters has been compared with all the centimeters of a decimeter scale of centimeters. The other is still to be compared with all the even two centimeters of the same scale.

Mr. Chapman is now comparing this decimeter scale with all the decimeters of a meter scale of decimeters. As soon as that is done *a meter* will have been compared with a wave-length. But shortly after, this will be improved by comparing the other gitter and also a third upon which I propose to measure a deviation. It will remain, first, to find the coefficient of expansion of the glass meter. The apparatus is all ready for this and it will not take a fortnight. Second, the glass meter will have to be compared with a brass meter. This will be an operation of some difficulty but I think we shall complete it before long.

Yours respectfully, C. S. PEIRCE, *Assistant.*

ART. VII.—*Notice of recent Additions to the Marine Fauna of the Eastern Coast of North America, No.* 6; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLIII.

POLYZOA.

Bugula decorata, sp. nov.

Zoarium rather large with thick, much branched stems, producing densely branched, somewhat plumose tufts, two inches or more high. Branches unequally dichotomous, often somewhat spirally arranged. Zoœcia in two alternating rows, large, broad, prolonged proximally. Frontal area, large, elongated, sunken and wrinkled in the dry state. The distal angles are prolonged into a single stout, often short spine on each side, frequently absent on the inner angle. Avicularia on the middle of the front side of the zoœcia, toward the base; they have a short, broad, swollen head, with a short strongly curved beak; the pedicels are short and thick, rapidly enlarged from the base upward. Oœcia large, globose, brilliantly iridescent, elegantly sculptured, with a series of raised curved lines passing up over each side and converging to the middle of front side, while their concave interspaces are covered with microscopic transverse lines. Dredged at Eastport, Me., by the writer, and also in the Gulf of Maine, 110 fathoms, near George's Bank, by Dr. A. S. Packard and Mr. C. Cooke, in 1872 (U. S. Fish Com.). The other species of *Bugula* found on the New England coast are as follows:

Bugula cucullata, sp. nov. Off Maine. Remarkable for the small, hood-like, upturned oœcia, widely open in front. Zoœcia in two rows; usually two spines on each angle; avicularia lateral.

Bugula turrita (Desor) Verrill. Florida to Casco Bay.

Bugula avicularia (L.) Oken. Long I. Sound to Spitzbergen.

Bugula fastigiata (L.) Alder (= *B. plumosa* Busk). Mass. Bay to Labrador; Europe. Perhaps a variety of the last.

Bugula flustroides (Lamx.) (= *B. flabellata* Gray). Long I. Sd. to Maine; Europe.

Bugula Murrayana Busk. Long I. Sd. to Europe.

B. Murrayana, var. *fruticosa* (Packard).

Bugula flexilis Verrill and *Bugula umbella* Smitt, belong to the genus *Kinetoskias* Dub. and Kor. Both occur in deep water off Maine and Nova Scotia.

Notwithstanding the very numerous restrictions which the ancient genus *Cellularia* has undergone, it is still made to include heterogeneous species by several recent writers, while others restrict it to groups not originally included by Pallas. In the excellent memoirs of Smitt on the Arctic Bryozoa, five species still remain in the genus *Cellularia*. These belong to three well-marked groups, and their synonymy is very

complicated. Having had occasion to revise this family, I offer the following summary of the New England species.

I. *Cellularia* Pallas, 1766, (restricted). Zoœcia unilateral, in two alternating rows, mostly protected by lateral spines, either simple or dilated. Vibracula and lateral and median avicularia present. Type *C. scruposa.**

a. Subgenus *Cellularia.* (=*Scrupocellaria, pars*, Gray, Busk). Lateral spines all simple.

b. Sub-genus *Cellarina* Van Ben. (incl. *Tricellaria* Flem., 1828.) One of the lateral spines usually more or less dilated, and often expanded in a shield-like form in front of the zoœcia. Two New England species: *C. scabra* Van Ben.; and *C. ternata* (Sol.) with varieties *gracilis* and *duplex* (Smitt).

The name *Tricellaria* (given to *ternata*), might have been adopted for this subgenus, but is very inapplicable to the group, and even to the type-species, as now known.

II. *Scruparia* Oken (restricted), (= *Scrupocellaria, pars*, Gray; *Canda* Busk, *non* Lamx.). Lateral avicularia and vibracula absent. A lateral spine develops into a protective (often frondose) shield. Type *S. reptans* (Linné), not yet found on the American coast.

III. *Bugulopsis* Verrill (= *Cellularia, pars*, Busk, *non* Pallas). Characterized by the simple, unarmed zoœcia, arranged in alternating rows, and destitute of avicularia, vibracula and shields. Type *B. Peachii* (Busk). Gulf of Maine and Bay of Fundy. European seas, north to Spitzbergen.

As no species of the last group was originally included in *Cellularia*, it is inadmissible to restrict that name to it. Therefore either *reptans* or *scruposa* should be taken as the type of *Cellularia*, both having been originally included by Pallas, as well as by most subsequent authors. *Scruparia*† Oken (1815) originally included not only the group that had previously been named *Eucratea* by Lamouroux (1812), but also *S. reptans*. Therefore there seems to be no good reason why it should not be restricted, as above, rather than be displaced by the much later and more objectionable name, *Scrupocellaria*. *Menipea*, used by Busk and others for *Cellarina*, is inadmissible, in that sense, for the original group thus named by Lamouroux is a valid and very distinct genus. *Canda* (Lamx., 1816), adopted by some for *Cellularia reptans*, cannot properly be so used, for the original type is a distinct genus.

Porellina stellata, sp. nov.

A large, handsome species, forming radiating patches on shells, etc. Zoœcia arranged in quincunx, large, broad, mod-

* This species has been recorded from the Gulf of St. Lawrence by Packard and others, but I have myself seen no American examples.

† This name has recently been given to a new genus, in a new sense, by Hincks, in accordance with a practice that is nearly always unsafe, as well as confusing.

erately convex, white, shining, mostly imperforate and smooth, the marginal ones more or less perforate in front. Apertures nearly semi-circular, the proximal edge straight or nearly so, often with two spines on the distal border, median pore, a short distance from the aperture, large, nearly circular, provided with numerous, slender, convergent spinules, which nearly reach the center, giving the pore a stellate appearance. Avicularia near the lateral margin, about opposite the median pore, varying in size and form: in the same colony some are short triangular, others long triangular, while others with a long and acute, erect tip show the transition toward vibracula. Length of zoœcia, ·60 to ·70mm; breadth, ·50 to ·60mm; breadth of apertures, ·12 to ·15mm; of median pore, ·05 to ·06mm. The zoœcia are about twice as large as those of *P. ciliata*.

Casco Bay, Maine. (U. S. Fish Comm., 1873).

In the nearly circular form of the median pore this species approaches the genus *Porina*, as restricted by Smitt, (Florida Bryozoa), but in all other respects, except size, it agrees so closely with *P. ciliata*, made the type of *Porellina* by Smitt, as to forbid a generic separation, although the latter has a crescent-shaped pore. It would belong to *Microporella* Hincks, if that name be adopted.

ART. VIII.—*Positions of the Planets Philomela and Adcona;* by C. H. F. PETERS.

I COMMUNICATE a few observations on a planet discovered by me on the 14th of May. I have given to it the name *Philomela*, as the name *Prokne* is applied to the one discovered on March 21. The planet lately found (May 21) by Mr. Palisa seems to be *Adcona* (145), which for several years had been searched for in vain, its elements having remained very uncertain, since my observations at its first appearance, the only ones made upon it, did not extend over more than about a month (from June 3 until July 7, 1875). I append the two positions I succeeded in getting before the last moon.

Observations on *Philomela* (196).

1879.	Ham. Coll. m. t.	App. *a*.	App. *δ*.	log (p. ″Δ)		No. of comp.
May 14.	11h 56m 31s	12h 16m 39s·02	+6° 52′ 46″·9	0·682	0·736	12
16.	10 37 6	12 16 21·21	6 48 5·7	0·509	0·724	10
18.	12 25 36	12 16 6·75	6 42 30·7	0·747	0·746	10
20.	9 51 4	12 15 58·20	6 36 57·0	0·391	0·723	12
25.	10 22 18	12 15 57·02	6 19 57·8	0·572	0·731	10
June 5.	10 6 55	12 17 37·14	+5 32 34·6	0·634	0·742	9

Observations on *Adcona* (145) (?).

1879.	Ham. Coll. m. t.	App. *a*.	App. *δ*.	log (p. ″Δ)		No. of comp.
May 28.	14h 27m 1s	15h 55m 11s·71	−15° 30′ 22″·8	0·677	0·851	8; 4
29.	12 40 30	15 54 18·81	−15 30 54·6	0·343	0·875	12

Litchfield Observatory of Hamilton College, Clinton, N. Y., June 6, 1879.

ART. IX.—*A Method of Preventing the too rapid Combustion of the Carbons in the Electric Lamp;* by H. W. WILEY.

IN using the electric light for projections, two chief points are to be considered, viz: 1st, brilliancy of illumination, and 2d, steadiness of the light. When the source of electricity is sufficient, the first of these ends is easily obtained. The second, however, is not so easy of accomplishment. The chief difficulty in the way of securing steadiness is found in the carbons themselves. Some carbons, and I find these to be the most common, burn away so rapidly that, where no mechanism is present to produce alternating currents, the electric arc is constantly passing out of the focus. Often, too, I have found that when the current is quite strong with the softer carbons, the arc would extend itself momentarily between points as far as a centimeter from the end of the carbons. At other times it would revolve about the electrodes something like a spiral flame in a pyrotechnic display. This leaping and dancing of the arc is, of course, fatal to its employment for projection.

In order, if possible, to remedy these defects in a lantern which I have in almost daily use, I made the following experiments. I first took the specific gravity of three specimens of carbon, obtained from different dealers, one in France and two in this country. The specific gravity of the French carbon, was 1·85; of No. 1, American, 1·53; of No. 2, American, 1·55. The French carbon is hard, of a grayish black color. The American carbon is soft, easily broken up, and has no sign of a metallic luster. The light from the French carbon is quite steady and displays very little of that tendency to flicker, so troublesome in the American varieties.

A positive French carbon, which had been used for several hours, until consumed nearly to the lamp, burned away at the point, but otherwise retained its original shape. This carbon was used without any previous preparation.

A soft carbon, however, of the same size as the preceding, became red hot to a distance of four to six centimeters from the end, and rapidly wasted away; after being in use for half an hour, it was reduced to a slender, tapering form.

I first tried the plan so well known in France, but so seldom tried here, of coating the carbons with a film of copper. The precipitation of the copper should take place slowly, and with a current so regulated in quantity and intensity as to produce no spongy deposits. When the soft carbons were thus prepared they worked beautifully for a short time. The light was brilliant and steady, while any green tint imparted to it by the volatilized copper produced no effect whatever prejudicial to

the purpose in view. But as the carbons, little by little, became heated, the copper film oxidized, and after half an hour the carbon was again reduced to the slender form above described.

I next tried the expedient of setting a copper wire, ·4^{mm} in diameter, into the center of the carbons. With a thin saw I cut a longitudinal groove to the center of the carbon, and after inserting the wire fixed it in place by filling the groove with plaster. The upper end of the wire was left projecting so that it could be brought into actual contact with the clamp. I hoped from this contrivance to hold the origin of the arc steadily at the end of the carbon and, at the same time by increasing the conducting power, to prevent the heating and consequent rapid consumption of the electrode. In placing the carbons in the lamp the grooved sides were turned from the lens. This device proved very successful in securing a steady light, but the carbons were heated to their points of insertion in the holders and wasted rapidly away. The point, it is true, remained blunt, but the stem of the carbon burned away so rapidly that the experiment must be regarded as unsuccessful.

It was evident from my first experiments with copper-plated carbons, that, if any way could be devised of protecting the copper from oxidation, the copper would prevent the carbon from heating by increasing its conductivity, and diminishing the resistance. I accordingly covered the carbons, after copper-plating with a film of plaster of Paris, about 1^{mm} in thickness. After this had set, the edge of the carbon, which was to be turned towards the condenser, was carefully denuded of its plaster-covering, which was also cut away until quite thin on the adjacent surfaces. These precautions were taken so that the plaster might not interfere with the radiation of light in the direction of the condenser. Before use the plaster must be thoroughly and slowly dried. The copper surface at the end of the carbon being uncovered it is fastened in the holder in the usual way. The carbons prepared in the way described left nothing to be desired. The light was steady and the carbons burned slowly away. The film of plaster melted gradually as the point was consumed and thus never interfered with the illumination. The points of both positive and negative carbons remained blunt, and there was no wasting away of the stem. A carbon prepared in this way will last at least ten times as long as one used in the ordinary way. But the chief advantage is found in the comparative steadiness of the light thus secured.

Carbons of the above description work best when well plated. The following numbers give what I regard as a minimum amount of copper to secure satisfactory results. In all

the experiments I have tried, the carbon has been of the soft American variety, with an average specific gravity of 1·55.

Length of carbon,	17·5 cm.
Each side,	1 "
Number $\frac{}{\text{cm.}^2}$ of surface including ends,	72 $\frac{}{\text{cm.}^2}$
Weight before coppering,	21·1615 g.
Weight after coppering,	24·0410 "
Weight of copper,	2·8795 "
Weight copper to each $\frac{}{\text{cm.}^2}$,	·0397

In order to dispense with the use of a reflector, I arrange the carbons + above as described in the Journal of Franklin Institute for May and June, 1878.

The peculiar cup-shaped appearance of the positive carbon helps to concentrate the light on the condenser. It is understood that any lamp, in which the carbons are arranged end to end, can be used with electrodes prepared as above. Such a lamp can be easily substituted in a lantern made for use with oxy-hydro-lime light. I use constantly such a lamp with one of Edgerton's physical lanterns originally made for the lime light. I am inclined to think a kaolin paste would be better than plaster for coating the carbons. The electric force used in all the experiments has been furnished by the Gramme machine, described in the Journal of the Franklin Institute already cited.

The use of projections for illustration in lectures on Chemistry and Physics has become so general that I hope the suggestions in this paper may prove of some benefit.

Purdue University, Lafayette, Indiana, April 18, 1879.

ART. X.—*Bernardinite: a new Mineral Resin from San Bernardino County, Cal.;* by J. M. STILLMAN, Ph.B.

THROUGH the kindness of Mr. B. B. Redding, of San Francisco, I have been put in possession of some specimens of a new and interesting mineral said to occur in considerable quantity in San Bernardino County, California, and exposed by excavations for a tunnel. The pieces in my possession were homogeneous masses of from one to five or six cubic inches dimensions, and appeared to have been broken from still larger masses. It presents a nearly white mass, friable, light and porous, containing much enclosed air, so that it floats on water like cork. On fracture it presents a slightly fibrous structure. Under the microscope it exhibits a two-fold structure—a quantity of very fine irregular fibers permeating a mass of a brittle, amorphous, structureless substance. No definite structure could be perceived indicating previous woody or vegetable

tissue. The specific gravity of the mineral freed from air was determined as 1·166 at 18° C. The mineral does not melt perfectly at 140° C., but softens *slightly* at temperatures below 100° C.

It is insoluble in water;—entirely soluble in hot absolute alcohol, about 86·6 per cent dissolving on boiling for some time. The soluble portion is quite soluble, remaining in solution in about 2½ parts of hot alcohol. In cold absolute alcohol it is not so soluble, about one-third of that portion soluble in hot alcohol, not re-dissolving in cold. The alcoholic solutions are of a slightly yellow color, marked bitter taste, and acid reaction. Ether dissolves about one-third of the native mineral at ordinary temperatures. Carbon disulphide dissolves it but slightly. The residues from the solutions were in every case white and amorphous.

The extract with hot alcohol melts at temperatures between 115° and 125° C., but has no constant melting point, and softens somewhat at lower temperatures. On cooling after fusion it forms a brittle, translucent mass. Heated on platinum foil the mineral burns with smoky flame, with fixed carbon residue, but with only a trace of ash. An ash determination gave 00·12 per cent of a white, infusible ash, evidently silica. With concentrated sulphuric acid it gives a red-brown color, which on warming becomes black; on dilution with water black flakes are precipitated. The mineral, dried for several days over sulphuric acid, lost on heating to temperatures below its melting point 3·87 per cent in weight, probably, though not certainly, water. It contains no nitrogen. Elementary analysis of the mineral dried over sulphuric acid gave—

Carbon	=	64·53 per cent.
Hydrogen	=	9·20 "
Hence Oxygen	=	26·27 "
		100·00

Admitting the loss in weight above quoted, of 3·87 per cent, as being due to loss of water, we should have as a complete analysis—

Water	3·87 per cent.
Carbon	64·46 "
Hydrogen (not in water)	8·75 "
Oxygen (not in water)	22·80 "
Ash	0·12 "
	100·00

In caustic potash the mineral dissolves very readily and almost completely (93·5 per cent). The solution when concentrated is of a light, clear, brownish-yellow, and may be diluted

to any extent with distilled water without precipitation, but with dilute chlorhydric acid gives a flocculent precipitate which settles to the bottom on standing. The alkaline solution is gelatinous in the cold when concentrated, but dissolves on dilution, and gives a froth like soap-suds on agitation. The portion insoluble in caustic potash (6·5 per cent) is left as a glue-like mass of a brownish color.

A quantity of the mineral was dissolved in caustic potash, precipitated with chlorhydric acid; the resin thus obtained was subjected after drying to elementary analysis. It gave—

Carbon	=	69·71 per cent.	} 100·00
Hydrogen	=	9·59 "	
Oxygen	=	20·70 "	

The melting point of this purified resin was determined at 127°–129° for perfect fusion, though softening at lower temperatures.

The acid character of the alcoholic solution, the oxygen contents, the behavior toward solvents, and especially toward caustic potash, as well as the temperature at which it melts, all indicate the resinous character of the new mineral. To confirm this it was treated in alcoholic solution with alcoholic solution of lead acetate, and a flocculent, white precipitate of the lead resinate was obtained. It is noticeable that the oxygen contents of this resin, as evidenced by both analyses, is much greater than is usually found in resins either of mineral origin or freshly obtained from plants.

The filtrate, obtained by dissolving in caustic potash and precipitating with chlorhydric acid, was evaporated to dryness and exhausted with alcohol, and a small quantity of a yellowish waxy substance obtained of an intense bitter taste, evidently the substance to which the bitter taste of the mineral as well as of its alcoholic extract is due, as the purified resin possessed no bitter taste.

This new resin appears to possess entirely different properties and composition from any organic mineral heretofore described. The South American mineral Guyaquillite seems to resemble it in some properties, but differs very materially in other essential properties as well as in composition. Berengelite, also from South America, possesses a somewhat similar elementary composition ($C_{20}H_{30}O_4$), but differs in all other essential properties. At the suggestion of Mr. Redding, to whom I am indebted for the specimens which form the subject of the foregoing examination, I propose the name of *Bernardinite* for the new mineral, from the name of the locality.

I hope soon to be able to subject the mineral to a more thorough investigation, with the object of ascertaining the true chemical nature of its constituents.

University of California, February, 1879.

ART. XI.—*Notice of a new Jurassic Mammal;* by Professor O. C. MARSH.

DURING a recent visit to the Rocky Mountains the writer spent some time in examining the deposits known as the Atlantosaurus beds, and was rewarded by the discovery of several interesting fossils, among them the lower jaw of a small mammal. This specimen indicates a dimunitive marsupial, quite distinct from the one previously described by the writer from the same horizon (*Dryolestes priscus*),* which has hitherto been the only mammal known from the Jurassic of this country.

The present specimen, which is from the left side, has the larger part of the ramus preserved, with a number of perfect teeth in position. Most of the symphysial portion is lost, and the posterior part is missing, or only faintly indicated. The jaw was remarkably long and slender. The horizontal portion is of nearly equal depth throughout, and the lower margin nearly straight. The form of the coronoid process, condyle, and angle of the jaw cannot be determined from this specimen.

The remarkable feature in this jaw is the series of premolar and molar teeth. These were very numerous, apparently as many as twelve in all, and possibly more. The premolars had their crowns more or less compressed, and recurved, and some of them were supported by two fangs. These had a small posterior tubercle at the base of the crown, but none in front. The molar teeth were all single-fanged, with elevated conical crowns. Those preserved have a distinct cingulum. The molars increase in size from the first to the fifth. All the teeth preserved have the crowns raised considerably above the upper margin of the jaw, and thus appear to be loosely inserted. A large pointed tooth lying near the jaw appears to be a canine.

The principal dimensions of this specimen are as follows:

Length of portion of jaw preserved	11·5 mm
Extent of five molar teeth	4·
Extent of entire molar series	5·
Height of fifth true molar above jaw	2·
Depth of jaw below fifth molar	1·75
Depth of jaw below last premolar	1·5
Depth of jaw below first premolar	1·4

In comparing this interesting fossil with the forms already known, it is at once evident that it differs widely from any living type. Its nearest affinities are clearly with the genus *Stylodon* of Owen, from the Purbeck beds of England,† and in many respects the correspondence is close.

* This Journal, vol. xv, p. 459, June, 1878.

† Geological Magazine, vol. iii, p. 199, 1866, and Palæontographical Society, vol. xxiv, p. 45, 1871.

This specimen clearly indicates a new genus, which may be called *Stylacodon*, and the species represented, *Stylacodon gracilis*. With the genus *Stylodon*, this form evidently constitutes a distinct family, which may appropriately be termed the *Stylodontidæ*. The present specimen indicates an animal somewhat smaller than a weasel, and probably insectivorous in habit.

Yale College, New Haven, June 18th, 1879.

ART. XII.—*On the Hudson River Age of the Taconic Schists;* by JAMES D. DANA. Supplement.

In the preceding part of this paper, the courses of the bedding of the rocks are indicated only in a general way. In this supplement, I give the results observed in Dutchess County as to strike and dip, together with some other omitted details.

1. *Wappinger-Valley Belt.* — This limestone belt leaves the Wappinger Valley about a mile northeast of Salt Point (or five miles from Pleasant Valley), the Creek—not the limestone belt—here changing its course by taking an eastward turn for a mile. From this point it has a small brook, flowing from Upton's Lake, as its southern limit, instead of the Wappinger stream; at the same time, its width—which was nearly a mile at Manchester, 3000 feet at Pleasant Valley, and, according to Professor Dwight, 2200 at Salt Point, continues to diminish; and, about half a mile west of Willow Brook station, the southern part of the belt ends. It appears again in the Wappinger Valley, about two and a half miles to the eastward, north of Bangall. The following are the results obtained with reference to the strike (or direction of bedding, allowance being made for variation, and the dip of the limestone and the associated schist) commencing at the south. As has been stated, the schist in Dutchess County, going from west to east, varies very gradually from dull to shining argillyte and thence to hydromica schist, on the north; and, on the south, from the same to mica schist and micaceous gneiss.

At East Mills, 4½m. S.E. of Poughkeepsie, the schist east of Wappinger Creek, strikes N. 39°–40° E., dip 75° E. (that is, eastward, but at right angles to the strike). At Manchester, limestone N. 17°–25° E., dip 50°–60° E.; schist, E. of river, N. 20°–21° E., 60° E.; the width of the limestone east of creek, about 2000 feet, and west of it, 3000 feet. At Rochdale (Titus's woolen factory) fossiliferous limestone, N. 37° E., dip 60° E. (650 feet west of the eastern junction with the slate). At Pleasant Valley, where the limestone is almost wholly north of the creek, N. 32° E., dip 85°–90° E., at a locality not far from its northwestern limit; and at the quarry near the river, about 200 yards from the southeastern limit, N. 24° E., dip 60° E. At Salt Point, according to Professor Dwight, N. 26° E., dip 70°–85° W. Southwest of Willow Brook ¾ m., limestone N. 19° E., dip 50°–60° E.; a mile east

of Willow Brook, S. side of Wappinger Creek, schist N. 16° E., dip 60° E., and ½ m. N.E. of last, N. 14° E., dip 50°–60° E. At Stanfordville, schist S. of river, N. 28° E. (average), dip 60° E. (varying, much contorted); 200 yards above station N. of river, *a layer of grayish quartzyte in the schist*, 25 to 30 feet thick, strike of slate and quartzyte, N. 16° E., dip 60° E.; just north of river ⅛ m. W. of Bangall, schist N. 28° E., dip 75° E., and here a fault, the limestone adjoining being nearly horizontal. Between Pine Plains and Stissingville, much of the limestone nearly horizontal, with small eastward dip, varying to westerly. At Stissingville near railroad, limestone N. 12° to 17° E., dip 40°–45° W., and schist near by, N. 12° E., same dip; one mile E. of station, dip 30° E. At Ancram Lead Mine, limestone N. 19° E., dip 60°–70° E.; 3 m. north, limestone N. 19° E., 50°–60° E.; in Copake, 1 m. south of village, limestone N. 13°–16° E., dip 40° E.; near Copake Iron Furnace, schist of Taconic Mtn., N. 10°–15° E., dip 50° E. (average); 3 m. S. of Furnace, adjoining Taconic Mtn., limestone and schist N. 15° E., dip 50° E.

2. *Shekomeko Limestone area.* — The area occupies the valley between Husted station and Pulver's Corners. Thence it extends south-southeast, widening, and ends half a mile south of where the road from Bangall enters the valley. In a cut just northeast of Husted station, limestone N. 25° E., dip 35° E.; schist in next cut, 400 yards to the northeast, N. 25° E., dip 40°–50° E.; 300 yards farther northeast, N. 14° E., dip 50°–60° E.; 1 m. eastward, schist of Winchell's Mtn., N. 16° E., dip 48° E.; on the mountain, 250 yards W. of Winchell's station, schist N. 16° E., dip 20°–60° E., average 40°. Nearly three miles S. of Husted's, just below Shekomeko station, limestone, N. 32°–37° E., dip 50°–60° E.; toward western limit of limestone area, an intercalated stratum of schist, N. 35° E., dip 50°–60° E.; west of this schist, limestone with same position; ¼ m. S. of Shekomeko station, limestone N. 27°–37° E., dip 15°–50° E. W. of south end of the limestone area, slate, near road to Bangall, N. 20°–32° E., dip in undulations, 10°–50° W., but ½ m. to the west, it is 40°–50° E.

3. *Fishkill-and-Millerton belt*, commencing at the southwest. —At Matteawan depot, argillaceous schist on railroad, N. 40° E., dip 70° to 80° E.—a fine-grained, fissile rock, of little luster, fusing B. B. to a slightly magnetic globule, and hence probably an argillitic mica or hydromica schist; ½ m. S.E. of Matteawan, at junction of schist and limestone, N. 52° E., dip 70° E.; ½ m. N.E. of Matteawan, limestone N. 42° E., 70°–80° E.; half way to Glenham (or 1 m. from Matteawan), limestone N. 47° E., vertical; ¾ m. southwest from Glenham, N. 52° E., 60° W.; again ½ m. from G., N. 47° E., 45°–50° W.; in Glenham, on river, limestone and "bastard granite" making parallel walls on opposite sides of the stream, strike of each, N. 37° E., dip 70°–80° E., and south of river, near mill-dam, limestone N. 52°–57° E., dip 35° W., north of river 300 yards, schist N. 22° E., dip 60°–70° E., with "bastard granite" near by to north much jointed and uncer-

tain in strike, becoming near the slate a gray quartzytic variety; north of Glenham station, on river, limestone N. 52°–62° E., dip 25° W. East of Fishkill station ½ m., limestone N. 52° E. (average), dip 55°–60° W. Between this and Brinkerhoff station, ⅛ m. from B., wide variations in strike and dip of limestone, N. 28° W., and even 55° W. to N. 12° E., dip 20°–35° E.; E. of B., ½ m., limestone N. 16° E., dip 50° E.; 1 m., same N. 2°–14° E., 50°–60° E.; 1¼ m. W. of Hopewell, limestone N. 40° E., dip 60° E. One mile southeast of Poughquag, 200 yards west of quartzyte, limestone N. 32° E., dip 40° W.; ½ m. S. of P., limestone N. 32° E., dip 40° E.; ½ m. W. of P., N. 37° E., 40°–50° E.; at Beekman's 1½ m. W. of P., limestone N. 22° E., dip 40°–50° E.; 3½ m. W. of P., north of Silver Lake, an intercalated stratum of contorted schist, N. 22° E., dip 65° E.; and west of this, beyond another limestone stratum, schist N. 12°–22° E., dip 50° E., but contorted; at Arthursburg, schist and limestone N. 12°–22° E., dip 50° E., but with undulations. At Clove Ore bed, limestone N. 37° E., dip E. 45°; schist of west slope of the mountain between Clove and S. Dover N. 52° to 60° E., dip E. varying in 1 m., eastward to N. 37° E., then on descent toward S. Dover, N. 22°–37° E. Nearly ¾ m. N.E. of Mabbitsville, schist contorted, N. 5° W. to N. 2° E., dip 50°–60° E.; 1 m. N.E., impure limestone, N. 6° W., dip 40°–50° E.; schist 2 m. W. of Wassaic N. 22° E., dip varying, 25°–30° E., to nearly horizontal; near Wassaic, schist N. 17°–22° E., dip 60°–70°; 2½ m. W. of Mabbitsville, at Millbrook, schist N. 19° E., dip 70° E. At Millerton, limestone in village, near upper railroad depot, nearly horizontal, dipping 10° to 20° E., strike about N. 12° E.; ½ to 1½ m. west of Millerton, along R.R., N. 10°–20° E., dip 5°–20° E., to horizontal, and 5°–10° W.; 2 m. west of M., on R. R., another large bed of limestone; ⅛ to ½ m. W. of M., schist (a thin, slivery, blackish slate) overlying the limestone nearly horizontally (as seen in section on the west); 1½ m. to 2 m. north of west of M., on R. R., the same schist, nearly horizontal over the limestone (as seen in section); 2½ to 3 m. northwest of M., along R.R., schist of Winchell's Mountain N. 20°–28° E. dip, 20°–50° E., the least on the east. Two and one-half m. south of Boston Corners, schist of eastern base of Winchell's Mtn., N. 12°–17° E., dip 20°–25° E., increasing to 45° nearer B. C.; schist of the body of the Mtn., N. 12°–18° E., dip 45° E.; at Boston Corners, close to Taconic Mtn., limestone and schist N. 13°–14° E., dip 70° E. At Weed's Ore Pit, in Southern Copake, 3 m. N. of B. C., schist N. 18° E., dip 62°–65° E.; and 1 m. W., limestone N. 12°–14° E., dip 50°–60° E.

At Verbank, slate N. 5° W. to 12° E., dip 50°–70° E.; limestone conformable to the slate, but much contorted.

The diversity in the strike near Brinckerhoff was probably caused by the spur of Archæan rocks, which reaches from the south nearly to the place. The schist west of Millerton has much luster in Winchell's Mountain, but very little farther east *where the beds are approximately horizontal.*

The quartzyte near Matteawan (see p. 385 of last volume) is situated *directly east* of this place, and extends along for half a mile.

Great Central Belt, commencing at the North.—In North Salisbury, Conn., ½ m. south of Massachusetts boundary, just east of the road nearest to the foot of the mountain, limestone N. 10°–12° E., dip 50°–60° W.; 1 m. to 2 m. farther south, N. 6°–12° E., dip 45°–60° W.; ½ m. east of the first of these loc., dip 50° E.; and 1¼ m. E., N. 15°–25° E., dip 50°–55° E.; at head of Wash-nee lake, limestone N. 16° E., dip 45°–55° E.; ½ m. S., N. 3° E., dip 40°–50° E.; at Chapinville, limestone N. 9° W., dip 20°–25° E.; 2 m. N. of Salisbury, mica schist, N. 15° E., 50°–60° E. In Lakeville, on lake, limestone N. 23° W., dip 50° E., and east of lake, limestone N. 18°–23° W., dip 20°–25° E.; 2½ m. east of Millerton, mica schist N. 8°–22° W., dip mostly 40° E.

In Sharon, ½ m. E. of Sharon Post Office, limestone N. 20° E. (average) dip 60° E.; 1½ m. to southeastward, gneiss, N. 26° E., dip E.; 2 m. to southward of Sharon, *quartzyte*, N. 26°–31° E., dip 60° E., the quartzyte in part schistose and containing some silvery mica, in other parts to eastward feldspathic and passing into granulyte, and the quartzyte and gneiss lying conformably along the east border of the limestone.

East of Wassaic, N. Y., limestone N. 12°–22° E., dip 45°–50° E.; 1½ m. S., limestone N. 26°–27° E., dip 55° E.; east of last, *quartzyte* (at quarry) N. 4° W., 40°–45° W. East of Dover Plains, 1 m., limestone N. 10°–20° E., dip 50°–60° E.; ½ m. farther east, and just east of the limestone area, quartzyte N. 10°–21° E., dip 50°–60° E.; ⅛ m. S.E., gneiss N. 10°–11° E., dip same. At South Dover, near R. R. station, limestone N. 20° E., dip 70°–80° E.; one mile north of Pawling, limestone N. 7° E., dip 70° E.; 1 m. E. of same, gneiss and mica schist N. 7° E., dip 70°–80° E., near Pawling Station, limestone N. 19° E., dip 60°–70° E.; and ½ m. to 1 m. W., same N. 2° E., dip 40°–70° E.; then nearly horizontal with dip westward and again eastward, and then 40°–50° E. prevails; 2 m. W., gneissoid mica schist or micaceous gneiss (just W. of a limonite ore bed) N. 2°–10° E., and varying to N. 32° E., dip 50° E. About Towner's (near the Archæan), gneiss underlying conformably the limestone, with wide variations in strike, N. 68° W., dip 40° E., but in hill to W., N. 38° W. to N. 88° W., dip E., about 40°; 1 m. S. of T., in the marshy valley, near a red house, the limestone interstratified with the gneiss, N. 32° E., dip 60° E. (the vicinity of the Archæan accounts for the contortions); ¼ m. N. of Dykeman's, whitish gneiss, N. 17° E., dip 70°–80° E.

The limestones of Dutchess County are distinctly fossiliferous only where, besides being imperfectly metamorphic, they do not contain seams of quartz, but instead calcareous seams, if any, as well as calcareous fossils. The quartz seams imply greater heat for the metamorphism; and when the penetrating moisture was thus rendered siliceous, the shells have been left as thin pieces of quartz, usually with little of the original form. The schist adjoining also has often its quartz seams or veins.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Action of Isomorphous salts in exciting the Crystallization of Supersaturated Solutions of each other.*—Thompson has studied the action of solid salts upon supersaturated solutions of other salts, isomorphous with these, to ascertain whether crystallization would be induced. When the salt used as the nucleus, as well as the other, formed a supersaturated solution, such a solution of the latter was placed in a small flask and a corresponding solution of the former, placed in a thin bulb tube was introduced into the flask, the liquid having been boiled and the mouth closed with cotton. The liquid in the flask was then boiled and its mouth was also stopped with cotton. After cooling, the liquid in the bulb tube was first caused to crystallize by a fragment of the same salt. It was then lowered into the liquid in the flask, and broken and the result observed. If the liquid in the bulb was not a supersaturated solution, it was allowed to crystallize on cooling before the bulb was broken. Another method was to use in place of the bulb, a doubly bent syphon tube containing the exciting liquid. In some cases a thoroughly washed nucleus was dropped into the supersaturated solution. The results showed that $MgSO_4\ (H_2O)_7$ was made to crystallize by the corresponding sulphates of zinc, nickel, cobalt, iron and magnesium, by $NiSO_4(H_2O)_6$, $FeSO_4(H_2O)_x$, and $CoSO_4(H_2O)_x$; while $MgK_2(SO_4)_2(H_2O)_6$, $Na_2SO_4(H_2O)_{10}$, $Na_2S_2O_3(H_2O)_5$, NaCl and glass had no action. $Na_2SO_4(H_2O)_{10}$ was made to crystallize by $Na_2SeO_4(H_2O)_{10}$ and $Na_2CrO_4(H_2O)_{10}$, but not by $MgSO_4(H_2O)_7$, Na_2SeO_4, $Na_2S_2O_3(H_3O)_5$, $Na_2HPO_4(H_2O)_{10}$, KCl, NaCl, $KClO_3$, $NaI(H_2O)_4$ or glass. Chrome and iron alums caused potassium aluminum alum to crystallize, while NaCl, FeS_2 (in cubes) and Fe_3O_4 (in octahedrons) did not. In the case of mixtures there are two cases: A, when the mixture contains two salts which are not isomorphous; and B, when the two salts are isomorphous. In the former case, (*a*) sudden crystallization takes place with a deposit only of the salt forming the nucleus; (*b*) the same, both salts being deposited but the one like the nucleus preponderating; and (*c*) the nucleus may slowly grow by accretion of its own salts from the solution. In the latter, (*a*) sudden crystallization takes place, both salts being deposited apparently in the ratio in which they exist in the solution; and (*b*) slow crystallization goes on, the least soluble salt being deposited. This latter case shows that there is a regular gradation from supersaturated to ordinary crystallization.—*J. Chem. Soc.*, xxxv, 196, May, 1879. G. F. B.

2. *On Ozone and the Silent Electric Discharge.*—Berthelot has observed some curious anomalies in the action of the silent electric discharge itself or of the ozone which it produces, upon chemical combination. Hydrogen and oxygen, for example,

mixed in the proportion of 2 : 1, do not combine under these circumstances even when submitted to the action of the silent discharge for several hours, with a spark in ordinary air of 7 or 8 cm. This result is the more remarkable, since oxygen under these conditions combines readily with the metals, sulphurous oxide, arsenous oxide, iodine, and even nitrogen. Carbonous oxide on the other hand, mixed with half its volume of oxygen, left after twelve hours only eight per cent uncombined, mixed with two per cent of oxygen; the rest having united with the mercury. A part of the CO had formed a brown oxide C_2O_3. Carbon dioxide under the action of the silent discharge, in a space free from oxidable bodies gives results which lead the author to suspect the existence of a percarbonic oxide CO_3. In one experiment, after twelve hours, sixteen per cent of the CO_2 was decomposed, and a gas was formed which attacked mercury and oxidable bodies with vigor. This cannot be ozone since in that case from thirty to forty-one per cent of the oxygen set free would have been converted into this substance, an unheard of proportion. The new body has not been isolated.—*Ann. Chim. Phys.*, V, xvii, 142, May, 1849. G. F. B.

3. *On the Occlusion of Hydrogen by Copper.*—JOHNSON has re-examined the result deduced by him from his earlier experiments, that metallic copper occluded an amount of hydrogen which might cause serious error in organic analysis; this result having been questioned by Thudichum. The copper to be tested was oxidized at the blowpipe, reduced in hydrogen, allowed to cool in that gas, the H displaced from the tube by dry air, the metal re-oxidized in a current of dry air, the water produced being collected in a weighed tube containing pumice moistened with sulphuric acid, special precautions being taken to exclude extraneous moisture. It was found that this occlusion actually took place, and that the pulverulent metal formed from the oxide reduced on the surface of the copper was most active, the amount occluded diminishing progressively as the metallic powder becomes denser by successive heating. A carefully conducted experiment showed the occlusion of 0·035 gram of hydrogen by 100 grams of copper. But curiously enough, it appeared that the finest precipitated copper oxide yields a finely divided metal on reduction, which does not occlude hydrogen. Moreover the author found that the copper thus hydrogenized, reduced potassium chlorate to chloride, and when ignited in CO_2 reduced it to CO. Heated in CO or in N, all its occluded hydrogen is given up. Heating alone in a vacuum does not set free the gas. The author therefore concludes that it is unsafe to employ copper freshly reduced in hydrogen for the reduction of oxides of nitrogen in organic analysis unless the metal be previously ignited in nitrogen gas.—*J. Chem. Soc.*, xxxv, 232, May, 1879. G. F. B.

4. *On the Composition of Charcoal from pure Cellulose.*—BERTHELOT has examined the charcoal produced from the pith of the spindle tree (*Euonymus*) in the process of carbonizing this

word for the manufacture of gunpowder. This charcoal therefore was made out of contact with the air and with the pyrogenic reaction products. After drying at 100°, during which it lost nine per cent, it was burned in a current of oxygen, and left 3·5 per cent of ash. The combustion afforded: carbon 73·6, hydrogen 2·2, potassium 2·1, oxygen 21·8, giving the formula $C_{124}H_{43}KO_{27}$; though no formula is actually probable of course. This charcoal contains oxygen much in excess of that which a simple hydrate of carbon requires, its amount being surprising. This is one of those special compounds of high molecular weight formed by successive condensations, carbon itself being the limit which is finally reached.—*Ann. Chim. Phys.*, V, xvii, 139, May, 1879.

G. F. B.

5. *On the Substitution derivatives of Nitrogen trichloride.*—Köhler has investigated the bodies discovered by Wurtz and considered by him derivatives of nitrogen trichloride. Tschermak first established the correctness of this supposition by acting on dichlorethylamine with zinc-ethyl and obtaining triethylamine. The author has confirmed these results and has produced the corresponding methyl compound, dichlormethylamine $N.CH_3.Cl.Cl$. It is a gold-yellow liquid, irritating to the eyes, boiling between 59° and 60°, and quite permanent. Köhler hopes by its means to produce the azo-compounds of the fatty series, by a reaction analogous to that by which phosphobenzene is produced from phosphenyl chloride and phenylphosphine.—*Ber. Berl. Chem. Ges.*, xii, 770, May, 1879.

G. F. B.

6. *On the Preparation of pure Cuprous chloride.*—The difficulties in the preparation of pure, dry and white cuprous chloride are well known. Rosenfeld having observed that the oxidation product of this body is converted into copper acetate by glacial acetic acid, while the cuprous chloride itself is only difficultly soluble in this liquid, has suggested a new method of preparation. By passing SO_2 gas into a mixture of equal molecules salt and copper sulphate in solution, the cuprous chloride is precipitated. This is collected on a vacuum filter, and washed first with SO_2 solution till this comes through colorless, and then with glacial acetic acid till the product appears perfectly white. The acid is drawn out of the precipitate by the vacuum, and this is pressed between paper and dried on the water bath, or in the air at ordinary temperatures. Thus made, it is a pure white powder composed of colorless tetrahedrons upon which strong sunlight has no action. Strong sulphuric acid scarcely acts on it. In the dark, dilute nitric acid is also without action; but when suspended in nitric acid diluted with six parts of water, the cuprous chloride is extraordinarily sensitive to light, the crystals becoming black with a luster like metallic copper, and suffering a true reduction.—*Ber. Berl. Chem. Ges.*, xii, 954, May, 1879.

G. F. B.

7. *On the Composition of Wood.*—Thomsen, noticing the considerable quantity of extract yielded to dilute sodium hydrate solution by birch wood, which extract was precipitated again

either on neutralizing with an acid or on the addition of alcohol, has made a systematic examination of the substance thus obtained. For this purpose sawdust from birch wood was treated with soda solution of 1·1 sp. gr. for 24 hours, diluted and filtered. The brown solution on saturation with H_2SO_4 deposited a whitish gelatinous precipitate. Alcohol acted similarly but the filtration was easier. After washing with alcohol and drying at 100°, it constituted fifteen per cent of the wood used. As it acts like a gum the author proposes to call it wood-gum. Subsequently a purer product was obtained by previously treating the wood with ammonia, and then with the soda. It afforded on analysis carbon 44·6, hydrogen 6·4, corresponding to the formula $C_6H_{10}O_5$. Comparative examinations of the quantity of this substance in various woods were then made, and the kinds examined by the sulphuric acid method arranged themselves in the following order in this respect: birch, ash, alder, cherry, white beech, oak, pear, beech, elm, willow, horse-chestnut, maple and pine, the last yielding only traces. The quantity was greater the nearer to the center of the tree the specimen was taken. Wood-gum is insoluble in cold water, but dissolves in fifty parts of boiling water, gelatinizing on cooling. It does not ferment after boiling with dilute sulphuric acid, does not reduce the copper test, and rotates to the left.—*J. prakt. Ch.*, II, xix, 146, March, 1879. G. F. B.

8. *Dust Figures produced by Sound Waves.*—Her. K. H. Shellbach and E. E. Boehm extend the work of Professors E. Mach and Fischer on the reflexion and refraction of sound contained in Pogg. Ann., cxlix, p. 421, 1873. By the use of fine coal dust strewn upon paper they were enabled to trace the effect of sound waves. When the prepared paper was placed beneath the spark produced by a Holtz machine, provided with large condensers, concentric rings appeared which were due to the sound waves. When the spark was produced between converging planes the waves of reflection of sound were clearly evident upon the prepared paper. The various theoretical laws in relation to caustics by reflection from spherical surfaces; the reflection from one focus of an ellipse to the other and the principle of Huggens in regard to the reflection of waves of light were distinctly shown to hold good experimentally in the case of sound. These experiments are analogous to those of Toppler, published many years ago. The latter physicist, however, gives a much more interesting way of studying sound waves by actually illuminating, so to speak, the wave itself.—*Annalen der Physik und Chemie*, No. 5, 1879, p. 1. J. T.

9. *Continuous Spectrum of Electric Sparks.*—Professor Anton Abt shows that the spectrum of the electric spark between two conductors in water and other fluids is a continuous one, and does not contain the lines which are apparent in the spectrum taken between metallic conductors in air. He attributes the continuous spectrum to the particles of the metals of the electrodes which are raised to a white heat but not to the gaseous condition which pro-

duces bands, when the spectrum of the spark in air is perceived.—*Annalen der Physik und Chemie*, No. 5, 1879, p. 159. J. T.

10. *A New Theory of Terrestrial Magnetism.* — Professors PERRY and AYRTON have proposed the following theory of terrestrial magnetism, which is based upon the experiments of Professor Rowland, of Johns Hopkins University, Baltimore, carried out in Professor Helmholtz's laboratory. In these experiments Professor Rowland showed that a magnetic needle is deflected by the movement of a static charge of electricity. Professor Rowland detailed to the writer of this notice, two years ago, in Cambridge, the same theory which is now proposed by Professors Perry and Ayrton. The theory is that the revolution of the earth beneath the electrical charge originally and at all times present in the atmosphere may and is sufficient to account for the magnetism of the earth.

Professors Perry and Ayrton have submitted the matter to calculation, and find that the difference of potential between the earth and space necessary to produce a distribution sufficient to produce the observed magnetic effect can be represented by fifty-four million Daniell cells. They prove, according to this theory that "if the earth be electrified, it must, from its very rotation, quite independently of all other bodies in the universe, be magnetic; and if it consist of a shell of iron, thick or thin, then that the law of distribution of magnetism produced by this electrical charge in mechanical rotation, will be identically that given by Biot; and, lastly, if the earth were wholly of iron, a difference of potentials of about fifty-four million volts between it and space would be sufficient to produce the necessary amount of charge.—*Phil. Mag.*, No. 45, p. 401, June, 1879. J. T.

11. *Experimental researches in Pure, Applied and Physical Chemistry;* by E. FRANKLAND, Ph.D., D.C.L., F.R.S., &c. 1047 pp. 8vo. London, 1877. (John Van Voorst).—Dr. Frankland has made a most acceptable gift to chemical literature and especially to the convenience of students, by bringing into one volume his numerous memoirs, extending over thirty years and scattered in various Journals and Transactions. The sixty-four memoirs here reproduced are pretty equally divided between pure, applied and physical chemistry. The rapid and fundamental changes in chemical philosophy and notation, which have occurred during the period covered by Dr. Frankland's memoirs, changes toward which his own researches have largely contributed, have required a thorough revision of the notation of his earlier papers. The volume opens well therefore with a reproduction of his "Contributions to the Notation of Organic and Inorganic Compounds" from the Journal of the Chemical Society (1866). The nine chapters devoted to pure chemistry contain some of the most important researches which mark the progress of discovery in organic chemistry. For example, the three memoirs on the "Isolation of the Alcohol Radicals," the nine memoirs on the "Synthesis of Organometallic bodies," the two synthetical researches on acids of the

lactic series, one on the acids of the acrylic series, and four on fatty acids. Each of these series of researches forms a continuous work and is prefaced by an analytical *resumée*, prepared for this volume, giving the author's mature views on reviewing the several subjects in the light of our present knowledge.

The experimental researches on various subjects in applied chemistry are full of interest; they include among the subjects, artificial light; the so-called hydro-carbon gas process; the gas supplied to London in 1851 and 1876; contributions to the knowledge of the manufacture of gas; on the igniting point of coal gas; and on magnesium as a source of light; all of which are replete with valuable data both theoretical and practical. The chapter on drinking water embraces, in six memoirs, a mass of valuable original research, as also does that on the purification of foul water, discussed in five memoirs. Every student of public hygiene as well as chemists will profit by the study of these chapters.

The memoirs on the influence of atmospheric pressure on combustion, and on the spectra of gases and vapors form the opening chapters in the section on Physical Chemistry, which is continued in memoirs on the source of muscular power and on climate.

Authors like Graham and Frankland (and we may add Rumford, whose collected memoirs the American Academy at Boston have lately made accessible) promote the progress of science not alone by the actual work done by them in original research, but possibly quite as much by the unconscious influence such collected memoirs exert by furnishing models of investigation worthy of imitation and stimulating others to a generous rivalry. B. S.

12. *A Guide to the Qualitative and Quantitative Analysis of the Urine, &c.;* by Drs. NEUBAUER and VOGEL, with a Preface by Professor FRESENIUS; translated from the seventh enlarged and revised German edition by Dr. Elbridge G. Cutler of Massachusetts General Hospital and assistant in the Medical School of Harvard University. Revised by Dr. Edward S. Wood, Professor of Chemistry in the Medical School of Harvard University. 551 pp. 8vo. New York, 1879. (William Wood & Co.).—A new translation of Neubauer and Vogel's well known work, which, since 1854, has passed through seven editions (to 1875) in the German, is a welcome and important contribution to the study of this special department of Chemistry. The translation of this work published by the Sydenham Society in 1863 was from the third edition, since which time very important changes in the text with numerous additions have rendered a new translation essential. No other work in the English language treats this department of chemistry in so systematic and thorough a manner, and it is risking little to say that this translation will come into general use wherever medical chemistry is taught as well as among chemists and physicians whose investigations demand a knowledge of the best methods of analysis and pathology in this direction. B. S.

13. C. GREVILLE WILLIAMS, F.R.S., of London, has just added a *Supplement to his Hand-book of Chemical Manipulation.* 88 pp.

8vo. London, 1879. (Van Voorst.)—This handbook, well known to chemists, contains notices of new methods of manipulation, with twenty-three figures of apparatus adapted for improved laboratory practice, and mostly selected from contemporary literature, with some things not before published. The selection is generally judicious and the supplement will be found useful in every working laboratory. B. S.

14. *Specific Gravity of the Vapors of Phosphoric Pentasulphide and Indium Chloride.*—Victor Meyer and Carl Meyer have determined the specific gravities of these vapors by the method of displacement which they devised and had previously described. They have found, in two determinations for the vapor of phosphoric pentasulphide, the specific gravities 110·1 and 110·7 when $H_2=1$ and for that of indium chloride the value 113·6. As the half molecular weight of P_2S_5 is 111, it is evident that this compound—unlike P_2Cl_5—is converted into vapor without disassociation; and since the specific gravity of the vapor of indium chloride corresponds very closely to that required for $InCl_3$, it would appear that this compound ought not to be classed with the sesquichlorides Fe_2Cl_6 and Al_2Cl_6, as chemists have been inclined to place it since the investigations of Bunsen on the specific heat of indium.—*Ber. der Deutsch Chem. Gesellsch.*, 28 April, 1879, p. 609.

II. Geology and Natural History.

1. *Die Dolomit-Riffe von Südtirol und Venetien. Beiträge zur Bildungsgeschichte der Alpen*, von E. Mojsisovics von Mojsvár. 552 pp. 8vo. Vienna, 1878. (Alfred Hölder.)—The Dolomite region of the Southern Tyrol is well known as one of the most remarkable portions of the Alps, both in the unique beauty of its scenery, and in the variety and interest of its geological structure. The strangely picturesque and wonderfully varied forms of the dolomite mountains, sometimes in perpendicular walls, and again as sharp jagged peaks, give the region a striking character of its own. Moreover, the peculiar interest connected with the study of them, as also that of the accompanying igneous rocks and the contact phenomena involved with them, has long made it a favorite region for geological study.

The present work gives a clear, comprehensive, and, at the same time, minute description of the geological relations of the whole region by one whose long experience in the study of the Eastern Alps has thoroughly fitted him for his work. In addition to the special description of each section of the country, with the numerous cuts and profile views, the work also includes several chapters of more general interest, and one of these contains a discussion of the Permian and Mesozoic Formations of the Eastern Alps. The closing chapters give the author's views in regard to the method of formation and time of elevation of the Dolomite peaks. He adopts the view, first put out by Richthofen in 1860,

that the dolomite mountains are true *coral reefs*, and finds confirmation for it in the massive unstratified character of the rock, and the fact that while poor in fossils they yet contain more corals than any other form of organic remains.

The work is accompanied by a large and finely executed geological chart in six sheets, and is moreover illustrated by thirty photo-engravings (Albertypes) which give an admirable idea of the most striking and beautiful features of the country, and are of great service in making clear the geological descriptions. E. S. D.

2. *A Native gelatinous Silicate.* — Prof. E. Renevier has described the occurrence of a gelatinous silicate, having the composition of chabazite. It was found in small fissures in the molasse, near Lausanne, Switzerland, on the occasion of the building of a tunnel. When first taken out it was in a gelatinous state, like semi-liquid starch paste. Its color was white, translucent, its luster was greasy, and the touch unctuous. In the air it dried rapidly, and at the end of some weeks it was transformed into a soft, white, sectile mass, having some consistency, and more or less plastic. If exposed still longer it became nearly solid, resembling steatite; in this condition it had about the hardness of talc, and its specific gravity was found to be 2·08—2·10. An analysis by Prof. Bischoff, on material dried at 100° C., afforded the following results:—

SiO_2	AlO_3	CaO	MgO	K_2O	H_2O
48·39	20·49	3·57	3·14	2·79	21·62=100·00

This corresponds closely with the composition of chabazite, and Renevier refers it to this species, but calls it a "mineral in an embryonic condition."—*Bull. Soc. Vaud. Sc. Nat.*, xvi, 81. E. S. D.

3. *Naturwissenschaftliche Beiträge zur Kenntniss der Kaukasusländer auf Grund seiner Sammelbeute herausgegeben*, von Dr. Oscar Schneider. 160 pp. 8vo, Dresden, 1878.—The extensive collections in natural history, mineralogy and geology, made by Dr. Schneider in the Caucasus during the summer of 1875, have been worked over in part by himself and in part by a number of specialists, and the results are contained in the present volume. The minerals have been studied by Professor Frenzel; among other points he describes a new species under the name of *urusite*. It was found with iron vitriol and other iron salts at Tscheleken. Its characters are as follows: it occurs in rounded masses, also pulverulent and earthy. The lumps are soft and easily crushed to a powder consisting of minute orthorhombic crystals. The specific gravity is 2·22; the color is orange yellow and the streak ochre yellow. An analysis gave: SO_3 42·08, FeO_3 21·28, Na_2O 16·50, H_2O 19·80 = 99·66. This corresponds to the formula $Na_4FeS_4O_{17}+8H_2O$.

4. *Mémoire sur le Fer Natif du Groenland et sur la Dolerite qui le renferme* par J. Lawrence Smith. (Annales de Chimie et de Physique, V, xvi, 1879).—The native iron of Ofivak, Greenland, was discovered by Professor Nordenskiöld in 1870, and by him described as of meteoric origin; later writers, however, have

been inclined to refer it to a terrestrial rather than to a cosmical source. This matter has been made the subject of an extended memoir by Dr. Lawrence Smith, and his conclusion that the iron is in fact terrestrial is so thoroughly proved that it can hardly be questioned in future. Dr. Smith describes in detail the several varieties of the iron and gives analyses of them; he has also investigated the dolerite in which the iron occurs both chemically and microscopically, and all the points are discussed with admirable thoroughness. The remarkable disintegration which has reduced many of the seemingly solid masses of iron to a fine powder, Dr. Smith attributes first to the loss of moisture, which results in the production of cracks in the surface, and then to the fact that the air, having access to the interior of the mass and meeting the iron in a finely divided state, rapidly causes its oxidation. An analysis of the unoxidized iron afforded the following results: G. = 6·42

Fe	Ni	Co	Cu	P	S	Cl	C (combined).
93·16	2·01	0·80	0·12	0·32	0·41	0·02	2·34 = 99·18

Other varieties of the iron associated with the dolerite gave somewhat different results, but all showed the presence of both nickel and cobalt. Associated with the iron in the dolerite were the following minerals: niccoliferous pyrrhotite, graphite, hisingerite, magnetite, spinel and corundum. Of these the graphite is the most interesting in relation to the explanation offered by Dr. Smith for this extensive occurrence of native iron. He argues that the basaltic rocks of Northern Greenland at the time of their eruption must have forced their way through lignitic miocene beds, setting free by their heat vast amounts of gaseous hydrocarbons, which would have exerted a powerful reducing effect on the iron oxides in the basalt. This would explain the considerable amount of combined carbon in the iron and also the large amount of graphite present in the rock. Dr. Smith has also reinvestigated some of the other so-called meteoric irons of Greenland, found at various localities for lat. N. 63° to 76°. He concludes that they are all similar to the Ofivak iron, and probably, like it, are of terrestrial origin.

5. *Jarosite* (*with Gold*).—This rather rare species occurs quite abundantly in the quartz veinstone of the Vulture gold mine in Arizona, whence I have received it from Mr. G. A. Treadwell. It fills cavities formed from the oxidation of pyrite. Fine transparent, yellow and dark brown, rhombic crystals—almost microscopic, are alternated with cryptocrystalline masses, in which, occasionally, are seen small brilliant particles of gold. The Vulture vein is enclosed in walls of a schistose gneiss or mica schist, and the atmospheric decomposition of the sulphide has been so complete that at a depth of nearly 300 feet only cubical cavities and a curious structure due to the removal of pyrite are observed, and the mine at that considerable depth is *completely dry*. B. S.

6. *The Botanical Text-book.* (*Sixth edition.*) *Part I. Structural Botany, or Organography on the basis of Morphology. To*

which is added the Principles of Taxonomy and Phytography, and a Glossary of Botanical Terms; by ASA GRAY, LL.D., etc., Fisher Professor of Natural History (Botany) in Harvard University. 442 pp. 8vo. New York and Chicago. 1879. (Ivison, Blakeman, Taylor and Company.)—The first edition of Dr. Gray's work was published in 1842: the year in which the author entered upon the duties of the Fisher Professorship at Cambridge. Six years before this, however, he had published a work entitled *The Elements of Botany*, which may be fairly regarded as a still earlier edition of the Text-book. The plan of this early work was generous in its scope, and was philosophically developed. A morphological basis was adopted as the only safe one on which to build, and upon this a symmetrical superstructure was erected. It was no ordinary sagacity which led a young botanist, without experience in teaching, to select a method which has needed no essential change for forty years, and which is to-day generally accepted as best adapted to elementary and advanced instruction. The "Text-book," which was developed from the earlier "Elements of Botany," has passed through several editions, the last of which, published in 1852, is widely known under the title, "Structural and Systematic Botany." A still further development of the plan selected at the outset, necessitated a division into separate volumes, and it is of this that mention must now be made. The present edition of the Text-book has outgrown its former limits and is to be embodied in four volumes. The first, devoted to Organography, upon the basis of Morphology, has just been published; the three remaining, to follow after a time, are to comprise respectively, Histology and Physiology, Cryptogamic Botany, Special Morphology of the Natural Orders. Other hands are to aid in preparing the second and third volumes. The arrangement of the early chapters in the present volume is nearly the same as that of former editions, but every section has been rewritten and considerable new matter added. Important changes have been made in the chapter on Inflorescence, or Anthotaxy. For the old names of the two types, the new ones, Botryose and Cymose have been substituted, and the forms of the latter are for the first time in English placed upon the satisfactory basis suggested by Eichler. The terminology of cymose clusters has, until recently, been much neglected, and has given rise to unnecessary confusion. An analytical table of the special kinds of definite, indefinite and mixed inflorescence is given at the end of the chapter, and will be found useful by students.

The sections devoted to the flower have undergone very great modifications. The deviations from the type-flower are discussed more fully than in any former edition, and the adaptive structures are described with considerable minuteness. It would be difficult to find a more succinct exposition of the mechanism of intercrossing than Dr. Gray has given in section IV. The special morphology of the stamens and pistil has been revised throughout and more copiously illustrated. It is instructive to observe how little

Dr. Gray's opinions respecting some mooted points of this subject have changed in the successive editions of the Text-book; in the present issue the author cites with quiet satisfaction the freshly discovered and weighty evidence in support of his early views. He adheres to his well-known belief, now well established, that placentæ belong to carpels and not to the cauline axis. He adopts the theory that ovules answer to leaf-lobes peculiarly transformed, or to outgrowths of a leaf, whether from its edges or surface. Under fruits and seeds, little new matter has been added, except a useful synopsis of simple fruits.

Thus far the work has dealt with Morphology and adaptations: the last part of the volume is devoted to Taxonomy. This presentation of the principles of classification may be fairly considered the most important chapter in the work, and an abstract must be made almost in the author's words. Holding the view that plants do not rise high enough in the scale of being to reach true individuality, the author takes as the analogue of the animal individual, the cell in the lowest grades of vegetable life, the phytomer (*phyton*) in the higher. "In botanical description and classification, by the individual is meant the herb, shrub, or tree, unless otherwise specified." "Species in biological natural history is a chain or series of organisms of which the links or component individuals are parent and offspring." "The two elements of species are: 1, community of origin; and, 2, similarity of the component individuals. But the degree of similarity is extremely variable, and the fact of genetic relationship can seldom be established by observation or historical evidence. It is from the likeness that the naturalist ordinarily decides that such and such individuals belong to one species. Still the likeness is a consequence of the genetic relationship; so that the *latter* is the real foundation of species." Variation within the species is next discussed, and it is shown that only observation can inform us how much difference is compatible with a common origin. The general result of observation is that plants and animals breed true from generation to generation within certain somewhat indeterminate limits of variation: that those individuals which resemble each other within such limits interbreed freely, while those with wider differences do not. Hence are recognized Varieties, or differences within the species, and Genera and other superior associations, in which the differences are more striking. Grades denote degrees of likeness or difference; but what is the explanation of the likeness between species themselves? With the accepted facts respecting variation, crossing and the like, before him, the author adopts the theory of descent and limitation by natural selection, to furnish an answer to the question just asked.

On page 330, the author says, "We have supposed . . . . that each plant has an internal tendency or predisposition to vary in some directions rather than in others; from which, under natural selection, the actual differentiations and adaptations have proceeded. Under this assumption and taken as a working hypothe-

sis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which, without it, are totally unanswerable." Following this comes a short section on the history of classification, in which is given an outline of the growth of the natural system.

The last chapter is devoted to Phytography. In this are given directions for describing plants in technical language, and for assigning names to new species in conformity with the canons of nomenclature. The fixation and precision of names is dealt with critically and at some length. Upon many points which have been held to be in dispute, the law is pretty authoritatively laid down. The important but too much neglected subject of herborizing and of preparing good dried specimens of flowering plants, is minutely and sensibly treated by Mr. Hoysradt. Directions for the formation and care of an Herbarium, and the study of dried specimens, are both as fully referred to as the space could warrant.

The volume closes with a long list of the signs and the chief abbreviations, including those of authors' names, occurring in systematic treatises. The index is an extensive glossary, in which, for the convenience of many, are given the Latin equivalents of most of the substantives and adjectives employed in botany. From the foregoing it must be seen that the present volume of the work is adapted, as we stated in the outset, to the wants of the advanced student and the working botanist alike.

G. L. G.

7. *Chronological History of Plants: Man's Record of his own existence illustrated through their names, uses, and companionship;* by CHARLES PICKERING, M. D. Boston, 1879. (Little, Brown & Co.)—This is a quarto volume of over twelve hundred closely printed pages, about half of which were already in type before the death of the learned author, which event took place March 17th, 1878. The remainder has been printed by his widow "in exact conformity with the manuscript." The work is arranged chronologically, and begins with the year 4713 B. C., the so-called Julian Period, followed immediately by 4491 B. C., the beginning of the first Great Year in the Egyptian reckoning. The first plant mentioned by Dr. Pickering is *Artemisia Judaica* of the desert of Sinai, which he considers to be the plant of the field of Genesis ii, 5, and the second is the tree which yields bdellium, probably a palm, *Borassus dichotomus*, though possibly a species of *Balsamodendron*. The remaining plants, animals, musical instruments and metals of the antediluvians are next considered, and then, with the year 4000, Jan. 1st, the ninth generation, he passes to the colonization of Egypt, and gives first a systematic list of the plants composing the Desert Flora, and then a similar list of the maritime Mediterranean Flora. Next follow forty-six pages devoted to Egyptian hieroglyphic signs, many of them primarily significant of natural objects. Other parts of the world, with the names of kings, writers, animals, plants and arts follow

year by year, or generation after generation, nearly everything spoken of being explained or interpreted by the author, until, turning page after page, we do not know which to wonder at more, his vast range of knowledge or his patience.

Had he lived he would doubtless have written his own Preface or Introduction, and in it have drawn his own general conclusions from so vast an array of facts. As it is, the work will remain, as Rev. Mr. Morrison says, a vast storehouse, from which other writers may draw the treasures with which they may enlighten their readers, or delight mankind. D. C. E.

III. Miscellaneous Scientific Intelligence.

1. *Fall of a Meteorite on the 10th of May, in Iowa;* letter from Professor S. F. Peckham to the editors, dated Minneapolis, May 29, 1879.—I have the pleasure of informing you that on the 10th of May, a meteor exploded and fell in full daylight at 5 P. M., at Esterville, Emmet County, Iowa. One of the fragments, weighing about 500 pounds, fell on railroad land and was dug up from a depth of fourteen feet in a stiff clay soil. Another smaller portion, weighing about 170 pounds, fell on the farm of A. A. Pingrey at a distance of two miles from the first. Many smaller pieces, of a few ounces or pounds weight, were scattered in the vicinity. The smaller mass fell upon a dry knoll and penetrated the earth vertically to a depth of 4½ feet. The fall was accompanied by a noise described as a continuous roll of thunder accompanied by a crackling sound.

Through the efforts of Professor E. J. Thompson of our Faculty the smaller mass has been obtained for the University cabinet. It is irregularly square in form, about 15×18 inches and of an average thickness of six inches.

A preliminary chemical examination shows the metallic portion to consist of an alloy of iron, nickel and tin. Full half the mass consists of stony matter, which appears in dark-green crystalline masses embedded in a light-gray matrix. When the whole is powdered, a violent reaction ensues on the addition of hydrochloric acid, which is increased on boiling. The boiling acid appeared to dissolve all but the gray matrix, abundance of iron passing into solution. Some of the crystalline masses are two inches in thickness, and exhibit distinct monoclinic cleavage. Under the microscope in thin sections, olivine, and a triclinic feldspar appear to be imbedded in a matrix of pyroxene. This work is in the hands of Professor C. W. Hall of the University who intends to make a very thorough investigation of the optical properties of the minerals and matrix.

The chemical examination was first attempted upon a very small quantity of material, but, now that we have an ample quantity, a complete analysis of the several minerals and the alloy will be made. A small piece of the metal polished and etched exhibited the Widmanstättian figures very finely.

The larger mass is still in the hands of those who dug it from the ground, although their ownership is contested by one who claims to have contracted for the land on which it fell. Their ideas regarding its value enlarge daily, the latest announcement being, that they should feel insulted at an offer of $5,000. We trust their feelings may be spared.

2. *The supposed Meteorite of Chicago;* from a letter to the editors from Professor E. S. BASTIN, dated Chicago, May 23, 1879.— * * * I have concluded that what was claimed to be a meteorite could not have been anything of the kind. A heavy shower was in progress at the time (April 9th), accompanied by thunder and lightning, and according to all accounts at the very moment the fragments of the supposed meteorite were seen to fall, there was a vivid flash and a loud report like that of a heavy stroke of lightning. The telephone wires in a dwelling house that stood only a few yards from the place where most of the glowing fragments were seen to fall, were melted as if by lightning, and more or less disturbance was caused in other wires and telephones about the neighborhood. It is reasonable, I think, to conclude that the glowing fragments that were seen to fall to the side-walk and to rebound from the roofs of buildings were fragments of the melted wires heated to incandescence. The fragments that were picked up that evening and the next morning and were claimed to be portions of the meteorite, do not resemble any meteoric matter I have ever seen. They look very like the slag from an iron furnace, and many fragments very similar to them in appearance may be picked up almost anywhere on our streets. A chemical examination of the specimens has shown that they possess none of the characters of true meteorites.

3. *Nordenskiöld's Swedish Arctic Expedition.* — The latest advices from Stockholm (about May 30th) indicate that telegraphic information had been received from Siberia to the effect that the Vega was in winter quarters in the vicinity of Cape Serdze-Kamen (Heart-of-Stone) in about lat. 67° N. and lon. 172° W. Letters had not been received, but were expected, being on their way from Irkutsk, and were said to be of the (latest) date of February 8th, in which the professor expressed a hope to be released by the ice in May. It is hardly likely that the opportunity will occur before July, since all previous experience shows the straits to be closed or impeded up to a date between the 1st and 15th of July, and often somewhat later. The position of the party is one which is free from ice every year, and there is little doubt but that the Professor will be able to carry out his idea of circumnavigating Europe and Asia in the Vega. The party at the date of writing were all well, and the letters had reached Yakutsk *via* Kolymsk by the hands of traveling natives.

WM. H. DALL.

4. *Eruption of Etna.*—The new eruption began on the 25th of May, and on the 28th, after two days of ejections of fiery cinders making clouds and rain of volcanic ashes of great extent,

the lava was seen flowing toward Randazzo. The new craters are situated near Monte Nero, 6,232 feet above the sea, and a fissure has been opened on that side (the northwest) of the mountain. The lavas have devastated the wood of Collebasso, destroyed the vineyards, and also a bridge across the Passo Pischiaro. The rate of flow on the 30th was one meter per minute. According to reports the stream has nearly reached Alcantara.—*Nature*, June 12.

5. *Influence of Coal-dust in Colliery Explosions.*—An investigation, by W. GALLOWAY, communicated to the Royal Society, on experiments as to the influence of coal-dust in colliery explosions, has led to the conclusion that: "Although the apparatus employed appears to be on too small a scale to solve the coal-dust question unequivocally, the results obtained with it appear to be sufficiently conclusive to enable us to affirm that an explosion, occurring in a dry mine, is liable to be indefinitely extended by the mixture of air and coal-dust, produced by the disturbance which it initiates. The only means of avoiding the dangers due to the presence of coal-dust in mines appears to be to carefully and constantly water the road-ways leading to and from the working places."

6. *Elephant Remains of Southwestern part of Washington Territory.*—Mr. J. T. Donald, describes in the Canadian Naturalist, vol. ix, no. 1, the discovery of a collection of bones, over 300, in a bog, twelve feet below the surface. They are referred to *Elephas primigenius*, var. *Jacksoni* (*E. Jacksoni* of Briggs and Foster).

7. "*On the Cudgegong Diamond-field, New South Wales.*" By NORMAN TAYLOR.—The diamonds of this locality occur in river-drift, associated with gold and other gems. The drifts in the district are at least six in number. The oldest is considered by the author to be Upper Miocene or Lower Pliocene; the next middle Pliocene; others Upper Pliocene, Pleistocene, and Recent. Between the Middle and Upper Pliocene flows of basalt lava took place which have sealed up much of the older drifts. Diamonds are found in the oldest drift and, probably by derivation from it, in the newer. Gold, metallic iron, wood, tin, brookite (?), iron-sand, quartz, tourmaline, garnet, pleonast, zircon, topaz, sapphire, ruby, and corundum are also found. The author then considers the question of whether the diamonds are derived from some of the igneous or sedimentary formations (from Upper Silurian to Mesozoic) which have contributed to the drift; and concludes, from a variety of reasons, that the diamonds have been formed *in situ* in the older drift.—*Phil. Mag., June, p.* 442, 1879.

8. *Report of the New York State Survey for the year* 1878, JAMES T. GARDNER, Director.—The third annual Report of Mr. Gardner contains a statement of the work accomplished in 1878, and is accompanied by four large maps showing the completed triangulation and its proposed extension during the coming season. The field work has been principally upon the central belt of triangles, which is to extend from Albany to Buffalo. The results

of the Survey thus far have been most important; they have revealed so great a degree of inaccuracy in existing maps of the State, that the completion of the work is seen to be a matter of the highest necessity. It is satisfactory to know that the appropriations for the present year have been already made.

9. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters.* Vol. iv, 1876–77. 320 pp. 8vo. Madison, Wisconsin, 1878 —The papers in the Department of Natural Science here published include the following: Notes on Cladocera, by E. A. Birge; on the Fauna of the Niagara and Upper Silurian rocks of Milwaukee County, Wisconsin, by F. H. Day; on the extent and significance of the Wisconsin Kettle Moraine, by T. C. Chamberlin; and papers on the Mound Builders, by E. Andrews, P. R. Hoy and J. N. de Hart.

10. *Ocean Wonders, a Companion for the Seaside, fully illustrated from living subjects;* by WM. E. DAMON. 230 pp. 12mo, with many illustrations. New York, 1879. (D. Appleton & Co.)—Many facts respecting the productions of the ocean are here presented in an attractive way, but at times with an eagerness for the wonderful and sensational that carries the descriptions quite beyond the actualities of nature. We think nature's wonders wonderful enough when presented as they are without exaggeration from fiction.

11. *Paris Academy of Sciences.*—Professor Asaph Hall has been elected a corresponding member of the Astronomical Section of the Paris Academy, to fill the place made vacant by the death of M. Santini.

12. *British Association.*—The 49th meeting will commence at Sheffield on Wednesday, Aug. 20, 1879. The President elect is Professor G. J. Allman.

13. *American Association.*—The next meeting will be held at Saratoga, commencing on the last Wednesday in August. Professor G. F. Barker is President.

14. *A Memoir of Joseph Henry: a Sketch of his Scientific work;* by WILLIAM B. TAYLOR. 140 pp. 8vo. Read before the Philosophical Society of Washington, Oct. 26, 1878.—An excellent memoir, admirable in its full, appreciative and learned discussion of the scientific labors and discoveries of Professor Henry.

15. *Observatory on Mount Etna.*—The plans of the Mount Etna Observatory, submitted to the Italian State Secretary for Public Buildings, have been sanctioned.

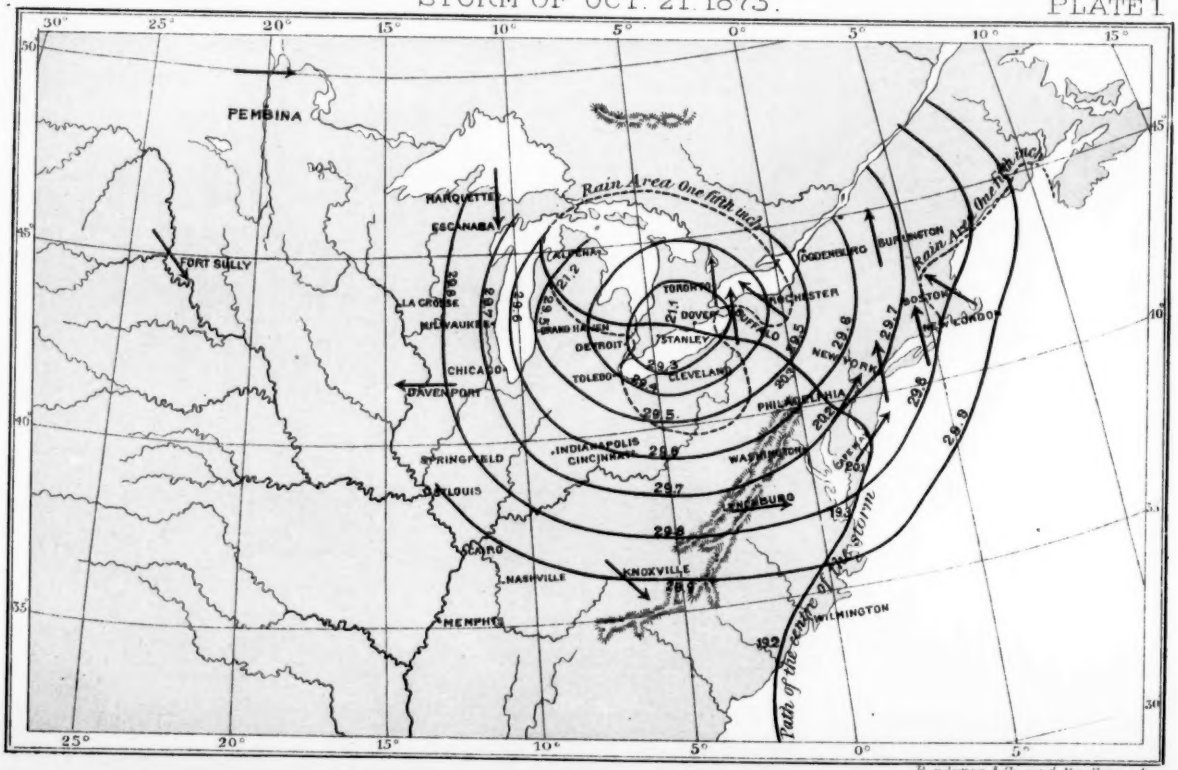
16. *Early Man in Britain and His Place in the Tertiary Period*, is the title of a new work by Professor Boyd Dawkins, soon to be published by Macmillan & Co.

OBITUARY.

Prof. PAOLO VOLPICELLI, the eminent electrician of Rome, died on the 14th of April.

STORM OF OCT. 21. 1873.

PLATE I



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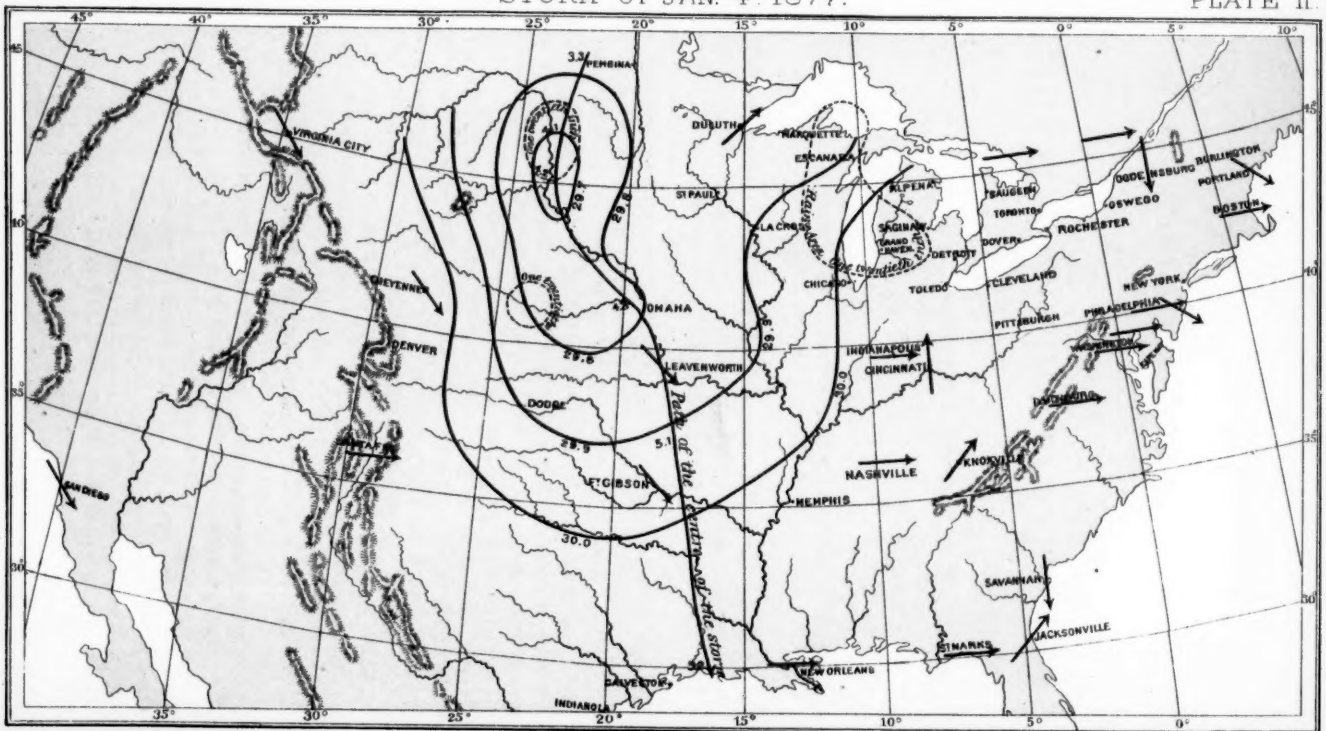
STORM OF JAN. 4. 1877. PLATE II.